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REPORT  
ON  
CONNECTICUT RIVER BASIN

BANK EROSION STUDY  
(RECONNAISSANCE REPORT)

NEW ENGLAND RIVER BASINS COMMISSION  
TECHNICAL COMMITTEE ON BANK EROSION

1 JUNE 1974

CONNECTICUT RIVER BASIN  
BANK EROSION STUDY

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31 January 1974
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New Hampshire and Vermont, New England Division,  
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CONNECTICUT RIVER BASIN  
BANK EROSION STUDY  
(RECONNAISSANCE REPORT)

1 June 1974

1. Background

The New England River Basins Commission held a quarterly meeting on 12 December 1973. At the request of the State of New Hampshire, the Commission approved the following motion:

"To authorize the Chairman to appoint a small ad hoc study committee of appropriate experts from various governmental units to assess river bank erosion, and other related matters, relative to the Federal Power Commission's relicensing of dams on the Connecticut River; and to report back expeditiously to the Chairman with their recommendations."

The New England River Basins Commission, by memorandum of 19 December 1973, requested that the Corps of Engineers chair a technical committee in response to the Commission resolution and to report back to the Commission. Accordingly, the Corps chaired an ad hoc committee to look into the erosion problem at the specified areas. This Interim Report is based on the studies of various members of the ad hoc committee.

2. Coordination

The Corps of Engineers held an initial Erosion Study meeting at the Corps' offices in Waltham, Massachusetts, on 31 January 1974. The following is a list of organizations that were invited to the meeting and were asked to participate in the study:

Corps of Engineers, New England Division  
U. S. Department of Agriculture, Soil Conservation Service  
U. S. Department of the Interior  
Environmental Protection Agency  
New England River Basins Commission  
Federal Power Commission  
State of New Hampshire  
State of Vermont  
New England Power Company

All of these organizations were represented at this meeting and each agreed to contribute to the study. The New England River Basins Commission was asked to use their Connecticut River Supplemental Study's public advisory structure to assist in this study. Accordingly, a member of the Science Advisory Group attended the Erosion Study meeting. The minutes of this meeting are included here as Attachment 1.

A final meeting was at the same location on 18 April 1974. The purpose of that meeting was to review and comment on the report which was in draft and to develop a final report with conclusions and recommendations. All of the participating organizations were represented at that meeting, and this report reflects opinions and views of participants. The attendance list of that final meeting is presented in Attachment 2.

This report was prepared by the Corps of Engineers. Drafts were circulated to study members for review and comment. Every effort was made to reconcile differences which arose on various matters; in some cases, differences were reconciled, and in other cases, the Corps of Engineers has, after reviewing the available data and consulting with other study members, presented what the Corps considers its best judgement on the matter.

### 3. Study Area

The study area consists of the reservoir banks and the river reaches between three hydroelectric projects on the Connecticut River in New Hampshire and Vermont. The three projects, Vernon, Bellows Falls and Wilder, are all owned by the New England Power Company (NEPCO). NEPCO has applied for a Federal Power Commission license renewal to continue operation at all three plants. The study area is shown on Figure 1; the reservoirs of Vernon, Bellows Falls and Wilder are shown on Plates 1, 2 and 3, respectively.

Vernon Dam is located at mile 141.9 on the Connecticut River, about 5.6 miles upstream of the Massachusetts State Line. Vernon Pool is about 27.7 miles long with its upstream limit near the New Hampshire Route 123 bridge in Walpole. Bellows Falls Dam is located at river mile 173.7 or about 4.1 miles upstream of the upper limit to the Vernon Pool. The Bellows Falls Pool inundates a 25.3 mile reach of the Connecticut River between Bellows Falls, Vermont and a point about a mile south of Windsor, Vermont. Wilder Dam, at mile 217.4 on the Connecticut River, is located about 18.4 miles upstream of the upper limit of the Bellows Falls Pool. Wilder Pool inundates about 45.5 miles of Connecticut River between Wilder, Vermont and a point 3.0 miles downstream of the Wells River.

The study involves a 121.0 mile reach of the Connecticut River between Vernon Dam and the upper limit of the Wilder Pool. The three hydroelectric projects in this reach of river impound water along a total of 98.5 miles of the river.

#### 4. The Erosion Problem

The Soil Conservation Service (SCS) reported on erosion problems from Vernon Dam to the headwaters of Wilder Pool. The work area consists of portions of six counties -- Cheshire, Sullivan and Grafton in New Hampshire, and Windham, Windsor and Orange in Vermont. Included were the areas of non-impounded river between the Vernon and Bellows Falls Pools and the Bellows Falls and Wilder Pools. The SCS report (Appendix A) presents the erosion problems on a county-by-county basis, as the data were collected. The data vary in the amount of detail. Very little is presented for Windham County, but lengths of eroded bank were presented for Cheshire and Grafton counties. Data for Sullivan, Windsor and Orange Counties include length of streambank eroded; annual loss estimates of earth volume and acreage; bank slope, as well as soil type and description.

On examination of the SCS report and maps, it becomes evident that erosion problems are widespread throughout the study area and fairly uniform; although the Wilder Pool does seem to have a slightly higher concentration of problem areas.

The SCS report reveals that 51.0 of the 242.0 miles, or 21.1%, of river bank investigated show erosion. SCS has estimated the annual loss of bank in both cubic yards and acres for Sullivan County, New Hampshire and Windsor and Orange Counties in Vermont. These three counties lose an estimated 19.6 acres of land or 215,000 cubic yards annually. Proportioning this to the length of shoreline in reservoirs of the three dams, it appears that approximately 32 acres or 350,000 cubic yards are being lost annually. This figure of land lost to erosion represents the gross values of area and volume actually removed from the banks. No effort was made to evaluate the amount of shoaling which is taking place at the same time. It is quite possible that the amount of new land being formed by deposition will equal the amount being lost.

The New England Power Company prepared a report (Appendix B) and furnished other information valuable to this investigation. The NEPCO information furnished, relates principally to the Wilder project and allows for a more detailed investigation than could be undertaken for the other two projects.<sup>1</sup> All three hydro projects are very similar in physical layout and operation, and the problems and causes at Wilder seem to be typical of what is happening at Bellows Falls and Vernon.

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<sup>1</sup> Considering the resources available to do this study.

The wealth of information gathered by NEPCO, owner of all three projects on Wilder, makes Wilder the most practical choice for this detailed examination. NEPCO is now in litigation on the relicensing of the three plants, and this litigation makes it inadvisable for them to furnish much of the information in their files as exhibits. The following, however, draws heavily on what NEPCO has provided.<sup>1</sup>

Wilder Dam is located on the Connecticut River, about two miles downstream of Hanover, New Hampshire. The pool, about 45-1/2 miles long, has its headwaters at Howard Island, about three miles downstream of Woodsville, New Hampshire. Plate 1 shows Wilder Dam and Reservoir. The 4.85 square miles of surface area would present excellent recreational opportunities except that water quality in the river is rather low. Despite this, the pond is active with boats in the summer and the shoreline is being developed. As existing water quality standards are met in the future, development pressures at Wilder will accelerate.

NEPCO, who owns the dam and either owns or has flowage rights on the shoreline of the reservoir, has encouraged recreational use of the pond with the construction of several boat launching ramps. They have not, however, encouraged development of the shoreline. Since NEPCO holds only flowage rights on most of the shoreline, they cannot control development along the shoreline. The Company seems concerned at the development which has been going on because much of it appears to be flood prone or erosion prone.

NEPCO has kept records of erosion in the Wilder Pond since Wilder Dam was reconstructed in 1950. The records since 1963 are meticulous; each area of erosion is recorded and photographed in each of four inspection trips in 1963, 1969, 1972 and 1973. The written records and photographs are indexed to a 1" = 1000' scale map of the 45-1/2 mile river reach between the dam and the Wells River. Areas that have been subjected to erosion are plotted to scale on the map together with areas that have been protected by riprap or other means. Other areas of natural and man-made activity are also shown on the map. The inspection write-ups describe each problem area in the pond and whether the area is actively eroding or in the process of healing.

On examining the records of the four inspections over 11 years, no pattern of increasing or decreasing of the erosion problem is evident. New problem areas are starting, some of the older ones are continuing and others are healing or have already healed over. NEPCO records show that almost 20% of the 91-mile shoreline of the Wilder Pool shows evidence of past or present erosion, but less than 5% appears to be actively eroding at any one time.

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<sup>1</sup> NEPCO, due to litigation on the relicensing of their hydro projects, felt it expedient to release certain information from their files only to the study chairman, for analysis and reporting. Much of the remaining portion of this section dealing with Wilder Pool is based on that analysis.

One pattern is evident from NEPCO's inspection records. As a general rule, erosion seems to be most active on curved reaches and then usually on the outside of the curve (that is, the bank having the greater arc radius). This is important because it suggests that flow velocities in the pond are probably a factor causing erosion. Normally, an unimpeded stream will erode its banks in this manner. The higher velocities of the water going around the outside of a curve will tend to scour the outside bank. The lower velocities on the inside of the curve will permit sediment to fall out of the water, creating shoals.

This appears to be what is happening in the Wilder Pool, and perhaps it can be explained by the fact that Wilder Reservoir is very small when compared to the drainage that flows into it. The active storage at Wilder contains only the equivalent of 0.07 inches of runoff from the watershed. Under average river flow conditions, the inflow to the Wilder Pool would be enough to completely replace the reservoir storage in a little more than a day's duration. A normal spring inflow of 5 cubic feet per second per square mile (csm) would provide enough water to replace the active contents of the reservoir about 2-1/2 times a day. The small storage and large drainage of Wilder Pool means that the reservoir is acting somewhat like a free flowing stream. Stream velocities are scouring in some locations and depositing in others.

NEPCO examined a 45-mile, free-flowing reach of the Connecticut River between Lancaster and Stewartstown, New Hampshire. A photographic record was made of this area. The examination of the 45-mile reach of free-flowing river above Lancaster was undertaken in order to have a natural reach to compare with the controlled reach at Wilder. The twenty-five photographs taken on 10 May 1973 indicate that there are erosion problems, on the natural reach of river, similar to those in the Wilder Pool. NEPCO seems to feel that the erosion problems at Wilder are nothing that wouldn't have occurred if Wilder Dam was not in existence.

The evidence suggests that stream velocity is a factor in erosion at Wilder. The question now becomes, is it the only significant factor. We know that rapid reservoir drawdown can result in high hydrostatic pressures in the adjacent river banks and resulting bank sloughing. In the case of Wilder, we have a daily operational drawdown and refilling of the reservoir. The operating pool range is between 385 and 380 feet mean sea level. Reservoir operating curves (hydrographs) plotted once daily from 1963 to 1973 show that the pool has stayed within these limits except for one instance, from the 12th to the 14th of May 1972, when the pool was drawn to elevation 374 to search for a drowning victim. This extreme drawdown was done at the request of the New

Hampshire Fish & Game Department. Although the pool has a 5-foot range, it is unusual for the pool to be drawn down more than two to three feet in any one day. According to NEPCO, the turbines at Wilder, when working at capacity and with no reservoir inflow, would draw the pool down at the rate of .4 feet per hour. From the eleven years of hydrographs and records of two to three feet of normal fluctuation, it appears that this rate of drawdown is not normally exercised through the entire 5-foot active pool range. Records of pool levels are kept at the dam and cannot be applied to the upper reaches of the power pool. Levels at the upper reaches are influenced by inflows and are not wholly controllable by Wilder Dam. Through most of the year, the pool is operated in the upper three feet, between elevation 382 and 385. When high spring flows exceed the usable flow at Wilder, the pool is drawn down to and maintained at elevation 380. According to NEPCO, this drawdown is made to reduce the backwater effect of high flows upstream. This pool fluctuation probably caused an increase in bank sloughing for a short period after the project was constructed. The sloughing probably returned to its original rate after the streambank had adjusted itself to the new water level.

One other factor in the erosion problem is worth noting. Water levels in the 45-1/2 mile reach of Wilder Pool are usually higher than they would be had Wilder not been constructed. This means that erosion problems which the reach of river is now experiencing would probably be different than if Wilder had not been constructed. The water levels being higher means that the water is scouring the banks at a higher level. It is impossible to predict how this might change the patterns of erosion; however, in the judgement of several committee members, there is no reason to believe that this modified water level will change the magnitude of the erosion problem.

It is important to note that there is a natural hydraulic control in the Connecticut River at Gilman Island, about a mile upstream of Wilder Dam. As river flows get higher in flood stage, the constriction at Gilman Island begins to assume control of river levels upstream. At the time Wilder Dam was reconstructed, NEPCO developed backwater curves to compare the new dam (pool elevation 380) with the old dam (pool elevation 370). At a flow of 5,000 cfs, the new dam raises stages at the Ompompanoosuc River by 14 feet and at Waits River by 12.7 feet. At 41,000 cfs, the new dam raises levels at the Ompompanoosuc by 2.2 feet and at Waits River by 0.3 feet; at 60,000 cfs, the new dam raises levels at the Ompompanoosuc by 1.2 feet and at Waits River by less than 0.1 foot. With a flow of 91,000 cfs, levels at the Ompompanoosuc and Waits Rivers would be the same with the new or the old dam. To put these figures in perspective, average flow in the river at Wilder is

about 5,800 cfs; the 1 July 1973 flood had a flow of 50,400 cfs<sup>1</sup> and the 1936 flood yielded a flow of 91,000 cfs<sup>1</sup>. The Ompompanoosuc River is 7.8 miles upstream of Wilder, and the Waits River is 30.3 miles upstream of Wilder.

This indicates that as flows increase beyond a certain point, Gilman Island begins to hydraulically control the river until a point is reached where Wilder Dam no longer has a significant effect on river stages upstream of Gilman Island.

Observations after unusually high river flows have indicated that the high flows have accelerated the rate of erosion. This would have been expected, but NEPCO and Soil Conservation Service people familiar with the river generally feel that extreme flows are responsible for most of the erosion in terms of total volume. Since river stages during extreme floods in most of Wilder Pool are little affected by the dam, it stands to reason that erosion caused by flows during the peak of a bad flood cannot be worsened by the dam. At periods of less than extreme floods, Wilder Dam does exert hydraulic control in the river above Gilman Island and the dam is certainly a factor in the erosion problem.

Waves are another factor in the erosion process. Waves are generated by wind conditions or boats or a combination of both. Natural waves in Wilder are small since the fetch in the long curvey pond is not enough to permit waves of a very high amplitude to be generated. Power boats on the other hand do produce larger waves. No attempt was made to compare the effect of an almost continual small natural wave action with the intermittent but larger wave action caused by boats. However, where wave action is the only erosive force acting on a bank, that bank will soon find its natural angle of repose and cease to erode. On the other hand, wave action will continue to slough banks that are continually undercut by a tractive erosion process. So, while waves might be the obvious reason for chunks of earth falling into the pond, we must look further to see why the chunk of earth was unstable before the wave hit it.

Poor land use practice is another obvious possible cause of erosion. Normally, we think of poor land use practice as a cause of sheet erosion; however, clearing trees and brush along a river bank will eliminate the root structure which goes a long way towards stabilizing the bank. Land clearing will, of course, accelerate runoff and can cause gulleys as the water runs into the river. These gulleys, in addition to carrying silt into the river will cause eddies which accelerate

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<sup>1</sup> Flood flows from NEPCO records.

erosion. Evidence of bank stripping can be seen in several locations and, as would be expected, erosion in these areas seems to be unusually bad. The information available is not adequate to make a quantitative estimate of how much bank stripping is contributing to the total erosion problem.

One other factor must be considered in analyzing erosion in the Wilder Pool. The argument has been heard that since Wilder Pool presents a wider cross section of water in the river than would occur under natural conditions, then a given flow will have less velocity than it would under natural conditions. On the surface, this is true; but since the turbines draw 9,600 cfs of water when operating under full load, it must be remembered that flow in the pond near the dam is also 9,600 cfs decreasing upstream from the effects of storage until the flow is equal to the pond inflow at the extreme upstream end of the pool. So whether or not the dam and pond increase or decrease flow velocities from natural conditions is not a simple question. Average flows over a long period of time are, of course, not changed by the project and average flow velocity is decreased due to the increased cross sectional area of the pond. It is not felt that the project increases the tractive erosion process due to increased velocities.

In summarizing these findings, Wilder Pool seems to be typical of the three dams under study. Erosion at Wilder appears to be more extensive than at the other two dams, but the abundance of information gathered through the years on Wilder Pool may be the reason for this impression. In any case, this abundant information makes Wilder the best case for a detailed analysis.

Wilder does indeed have an erosion problem; about 20 percent of the reservoir shoreline shows signs of past or present erosion. New England Power Company has made rigorous inspections and reports on the problem in 1963, 1969, 1972 and 1973.

The pool shoreline erodes much like the banks would erode in a free flowing stream with scouring on the outside of curves and shoaling at the inside of curves, caused by the movement of water through the pond. The reservoir obviously causes erosion to take place at a higher level on the bank than would be the case if the dam had not been constructed. Based on the information available,<sup>1</sup> there is no clear indication that the magnitude of the erosion problem has been greatly affected by the existence of Wilder Dam.

NEPCO either owns outright or has secured flowage rights on virtually all the land which has been sloughing; however, development of land

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<sup>1</sup> See footnote on Page 4.



near the river has made bank sloughing a cause for concern in recent years. Much work has been done in recent years to protect the shoreline. The most notable example is a 10,000 foot reach of shoreline which was riprapped in Hanover, New Hampshire. If the banks are to be made secure from sloughing, much more bank protection must be anticipated in the future. Detailed soils investigations must be made to identify erosion prone banks.

Should the decision be made to let the banks continue in their present erosion patterns, then a detailed study must be made to identify what will be the problem areas in the future and then positive action must be taken to keep future development out of these areas. If this latter course of action is pursued, measures should be taken to remove structures from the existing problem areas or protect the shoreline near these structures from further erosion.

In view of the pressure to develop the shoreline of Wilder Pool, it seems imperative that studies be conducted to ascertain what land should be available for development and what shoreline should remain in natural state.

#### 5. Environmental Considerations

It has been established within this report that erosion may be attributed to several causes including natural phenomena, poor land use practices, and possibly hydroelectric water level manipulation. If the Connecticut River is allowed to be a true riverine system and not a part-time lacustrine part-time riverine one, erosion may not be as serious a problem to the biological resources of the river. The "normal" process of silt carriage and deposition would continue. However, the river is manipulated on a continuous daily, weekly and seasonal basis. The eroded material appears to be deposited in a way that adversely affects the fishery resources. Benthic organisms may also be affected by the pattern of erosion.

#### 6. Further Studies

The efforts of this study, have, for the most part, been directed to analyzing existing information and drawing whatever conclusions that are possible considering the nature and extent of the available information. Very little effort has been spent on collecting new data.

It has been found that adequate information is available so that an accurate assessment can be made of the extent of the erosion problem.

Sites of past and present bank sloughing have been identified, photographed and mapped. The length, depth, area and volume of land lost have been recorded to an extent where a fairly accurate estimate of total erosion can be made.

Certain information gaps have become evident during the course of this study. The information which is available provides a pretty good picture of the history of erosion, but this information does not permit us to predict what erosion problems will occur in the future or how we might deal with these problems. Soils information in the detail necessary to deal with the erosion problem simply does not exist.

Development along the river now and in the past has been a hit or miss proposition. If a person guessed right, he had good shoreline property for his home; if he guessed wrong, his house fell into the river. An example of the latter case is the Charlestown, New Hampshire Wastewater Treatment Plant. In 1964, the town of Charlestown built its treatment plant on land acquired from NEPCO. NEPCO indicated its reservations about the property being suitable for development. The town felt that a site, some 120 feet from the river bank, would be safe. By 1968, the river had moved to within 85 feet of the plant; in 1971, the river was 66 feet away. Extrapolating we can see that the river will be undercutting the treatment plant in about 5 more years. The Corps of Engineers estimated in 1971 that \$56,000 in bank protection was necessary to protect the \$80,000 invested in the plant, constructed only 7 years earlier. This case is not unique, many homes are endangered now and many more will become endangered in the future as the river continues its natural meandering.

The U. S. House of Representatives, House Committee on Public Works, on 11 April 1974, adopted a resolution, requesting that the Corps of Engineers study erosion problems behind the Wilder, Bellows Falls, Vernon and Turners Falls Projects. The resolution which was introduced by Congressman Cleveland of New Hampshire states:

#### RESOLUTION

"Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the report on the land and water resources of the New England - New York Region, requested by the Flood Control Act of 1950 and published as Senate Document No. 14, Eighty-fifth Congress, First Session, to study the

erosion problems behind the Wilder, Bellows Falls, Vernon, and Turners Falls Dams and to make recommendations for any changes in the operation of the dams or such remedial measures as would minimize erosion in Wilder Lake and the banks of the Connecticut River downstream to Turners Falls in Massachusetts. The study should include any factors which might affect river bank erosion such as weathering, raising and lowering of lake levels, wave action, river velocities, sedimentation conditions, types of soils, frost effects, vegetation cover and root patterns."

The study envisioned consists of soils investigations, hydrologic studies, surveys and mapping, stream regulation studies, design and cost estimating, economic studies, real estate studies, and environmental studies. The end result would be a survey report which would make recommendations to Congress.

It has become evident that bank erosion is a serious problem in the area under study; it makes development along the shoreline of Vernon, Bellows Falls and Wilder Pools a hazardous undertaking. Development pressures on this desirable shoreline property will certainly increase in the future unless something is done. The study which has been authorized by the House Public Works Committee is necessary so that solutions to the erosion problem can be identified and recommended. Changes in the operation of the dams will be considered along with other remedial measures in the problem areas. Certain erosion prone areas might be identified with recommendations that they be zoned out of development. In other cases, shoreline protection might be the answer. Whatever the case, before action is taken, the cost must be determined; the cost in dollars, the cost to the environment, and the social costs to the people that would be affected.

## 7. Conclusions and Recommendations

The conclusions and recommendations, based on this report, must first be qualified by the conditions under which the study was undertaken. The study has been a two-month long unfunded reconnaissance effort by six Federal Agencies, two states and one private company. The study has taken place in the winter months of January, February and March 1974, so that a minimum of field investigation was possible. The little field investigation that was undertaken was not as effective as it would have been during the summer months.

## Conclusions

A. There is a widespread bank erosion problem in the 121.0 mile reach of Connecticut River between Vernon Dam and the headwaters to the Wilder reservoir on both the New Hampshire and Vermont shoreline. Land of stream abutters is being lost. Silting due in part to this bank erosion, has an adverse effect on the river's fish population, water quality, and aesthetics.

B. This problem can be expected to continue at about the present rate with a gross<sup>1</sup> rate of some 32 acres or 350,000 cubic yards of earth lost annually. Some existing problem areas will continue to erode, some will heal and new areas of erosion can be expected to develop.

C. The three hydroelectric projects do modify the erosion patterns from what would be a natural situation. There is, however, no clear evidence that the magnitude of the erosion problem has or has not been greatly changed by the construction and operation of the three projects.

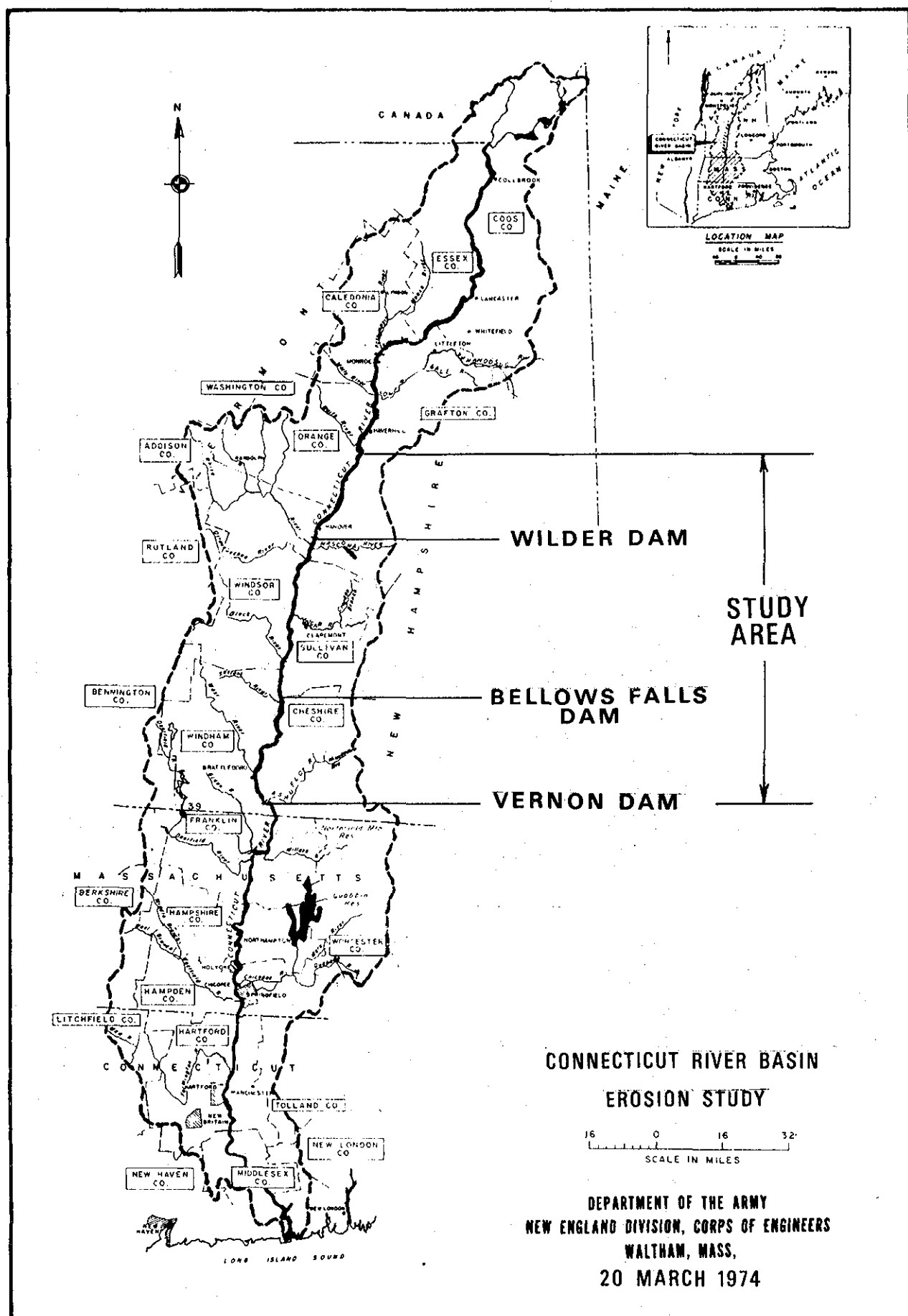
D. Several information gaps have become evident during the course of the study. While the extent of the existing erosion problem is generally evident, the forces which cause the problem are not well understood. Soils information is not adequate and not enough is known about flow patterns in the river both in normal and flood conditions. More should be learned about the effects of erosion on the river's biota, especially with regards to silting. Information is not available on the sources of depositions in the river; for instance, we don't know the relation of shoaling to erosion.

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<sup>1</sup> It is recognized that while some bank is being lost to the erosion process, siltation or shoaling is creating new land. No attempt has been made to estimate the amount of new land being created by this shoaling.

### Recommendations

- A. That detailed soils, engineering, economic and environmental studies be conducted to determine and map exactly which areas along the shoreline of the Connecticut River are erosion prone. Dollar, social and environmental benefits and costs of providing bank protection, zoning, or making reservoir operational changes should be developed and compared.
- B. That the appropriate states and communities should develop or adjust their master plans and zoning ordinances to reflect the findings of the study mentioned in Recommendation A.
- C. That the question of streambank erosion, having certain environmental implications, should be addressed by the Federal Power Commission in its preparation of an Environmental Impact Statement for the Vernon, Bellows Falls and Wilder project relicensings.
- D. The relicensing procedures for the three dams should proceed as presently scheduled, and not be delayed pending completion of studies recommended under "A" above.











## MEETING SUMMARY

### CONNECTICUT RIVER BANK EROSION STUDY

31 January 1974

SUBJECT: Summary of the Meeting 31 January 1974 of the Technical Committee on Bank Erosion in Connection with the Connecticut River Dam Re-Licensing

1. The meeting began with an introduction by Colonel Mason who explained, in essence, the mission of the committee was to provide a report to the 20 March NERBC meeting with respect to the nature of the erosion problem, the apparent causes of the erosion problems, relationships to relicensing, and any recommendations which the committee may wish to offer to assist us in resolving the problem. He then noted that John T. Smith, of his Planning staff, would represent him as a member on the technical committee.

2. John Smith distributed a copy of the agenda for the day, copy of which is attached, along with the attendance for the meeting. After the attendees had each introduced himself, the scope of the study and the study area was discussed as follows:

At the December New England River Basins Commission quarterly meeting, Mr. James Minnoch from New Hampshire submitted a motion to authorize Mr. Gregg to appoint a small study group from various organizations to assess bank erosion problems at three hydroelectric dams (Vernon, Bellows Falls, and Wilder) which are up for relicensing. The motion was passed by the Commission; and Mr. Gregg, by memorandum, asked the Corps to chair the study. The memorandum, which Mr. Gregg sent to the Corps, was attached to the letters of invitation sent to those participating. It was noted that New Hampshire is particularly interested in the problems at the three plants. New England Power Company owns all three plants. The Federal Power Commission is the licensing authority for these plants, and to date FPC has not acted on the application.

3. Apparently, there is a problem of bank sloughing in the power pools of the plants and the Commission has specifically asked that the study respond to three areas: (1) extent and nature of the problem; (2) relationship with the relicensing of the New England Power Company Dams and (3) recommendations to resolve the problem.

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Attachment 1

4. Under scheduling and reporting, Agenda Item 3, there was considerable discussion as to the short-term nature of the work of the committee, and the fact that everything would have to be done expeditiously if we were to be able to report at the 20 March NERBC Quarterly Meeting. It was pointed out that the Committee would only have time to make a list of the kinds of information that are available -- who has it, where is it, and what the extent of that information is. This information would be provided in the form of reports from each of the participating agencies; specifically, the Corps, SCS, Bureau of Sport Fisheries and Wildlife, and EPA. The States and other Federal agencies, and the New England Power Company were invited to submit reports if they wished. At this stage in the meeting, it was not certain as to what kinds of information were available. It was decided to wait until agenda item 5 was discussed before setting schedule dates. We then moved on to agenda item 4.

5. Under agenda item 4, John Smith and Hank Baker, NED Soils Engineer, discussed the general forms of bank erosion, which may be taking place. They generally break down into two categories -- those caused by natural flows, stream velocity, or those caused by fluctuation of the pool. It was noted that both are natural processes which go on continually to some extent in all streams. In the first category, high velocities caused by flood flows accelerate this process. The material is literally gouged off the stream bank. In the second type, the erosion is caused by rapid changes in reservoir or stream level. When the water level is drawn down fast, the stream level becomes lower than the corresponding groundwater level in the adjoining bank, and the water which is stored in the bank then flows out under pressure into the stream. If the head on the groundwater is abnormally high, then the velocities through the soil of the bank are very high and the fine particles are washed out and weaken the structure of the soil. The weight of heavy rain falling on a bank already undercut by an erosion process can cause that bank to fail.

6. Under agenda item 5, Exchange of Information, Ed Plumley of New England Power noted that his company had applied for some six years for a long-term license for the three plants and various interests had intervened in the application for relicensing. Because of the intervention and the fact that intervenors are present on the committee, the New England Power Company does not wish to jeopardize its legal position with respect to the FPC decision on relicensing. In response, Larry Dingman noted that he had resigned as a director of For Land's Sake early in December and that he is still a member. For Land's Sake is an intervenor in the relicensing of the three hydro plants. Also,

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Dr. Brower noted that although she is representing the Science Advisory Group, she does also represent the Massachusetts Public Interest Research Group which is an intervenor. In essence, then, there was a question on the release of technical data, and Ed noted that he would check with the company attorney before making a decision on which information their firm could release.

7. James Minnoch, Office of State Planning of New Hampshire, speaking for the State, felt that a technical study of the erosion problem is needed. He felt that there is sufficient data necessary to preclude extensive study and that the main interest is to assure that New Hampshire is well coordinated on the problem. He feels that the findings of the technical committee could be used in the public hearings on the relicensing. Mr. Grob of the FPC noted that formal hearings with respect to the relicensing are planned, but as yet are not scheduled.

8. There was considerable discussion as to the extent and nature of the information which is currently available. In summary, the following information was noted:

a. The Connecticut River Basin report contains a general position on the overall effect of erosion and sedimentation in the basin. Erosion is discussed in Appendix F.

b. In 1969, the Corps and SCS made an erosion assessment which has some generalized information on erosion but nothing of any detail that would be helpful in our study.

c. Photos -- there are 1969 photos of I-91 at 1" = 2,000'. CRREL - the Cold Regions Resource Engineering Laboratory has 1973 photos of sloughing areas in Wilder Pool. They also have low level aerial obliques when the pool was drawn down in 1973, some eight feet. There are a series of vertical photos or photogrammetry of the basin, dating back as early as 1939. Vermont has 1962 photos at 1" = 1,500', and 1969 photos of southern Vermont at 1" = 2,000'. Vermont also has photos of I-91, five foot contours 1" = 200' -- all the way up to St. Johnsbury, and also some old file photos which could be looked at to see whether they are pertinent. As to the usefulness of photos, there was some doubt as to whether the photos would be helpful in determining the extent of the erosion.

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d. Soil Mapping -- The Soil Conservation Service has extensive soil mapping which is oriented to agricultural use dealing with the top four to five feet of over-burden. Since 1950, the soil has been classified in two different ways -- one primarily agricultural, and the second on a general scientific sense.

The entire New Hampshire shoreline is done on the old method, by counties, and several portions have also been done by the new methods. Soil types were done for Vermont for the CRB Study and land use classifications are available. Keith MacPherson of SCS noted that he would ask the SCS county agents to prepare report information for him.

9. George Morrison of the New Hampshire Fish and Game said that he would cooperate with Peggy Kohl of U. S. Fish and Wildlife in providing information to the committee. Morrison's office has extensive raw data on the river, although it hasn't been developed in a form which would lend itself to submission to the committee. In reference to delineating the extent of the erosion, he felt that the only way to really view the river banks is by boat and by water. He did not feel that the aerial photos would lend much help and he stated that the highways did not go close enough to the river bank in enough places to be helpful in the overall problem. Larry Dingman felt that you could get an idea of the overall extent by examining the photos, but you would have to make a field inspection to determine the nature of the problem. Ed Plumley of New England Power noted that his office has extensive records of the operation of the pools which will be essential in the determination of the nature of the problem. He said much of this information is already available in the New England Division office. He felt we needed to compare the natural stream condition with artificial conditions imposed by the reservoirs. Jim Kohler of EPA felt that a number of questions ought to be responded to. They dealt with the fluctuation of the pool, the groundwater response to fluctuation, soil type saturation condition, the seasonal affect of erosion, seasonal occurrence of erosion and the silt or sedimentation load in the river. Hank Baker felt that where For Land's Sake had been an intervenor in the relicensing because of the erosion problem, we ought to get a copy of their statement to FPC. Dr. Brower felt that the statement provided by For Land's Sake would be too general to be helpful to a detailed study.

10. At the close of the meeting, John Smith summarized the accomplishments of the meeting and after some discussion it was agreed that the agencies would provide their reports to John by 20 February. John would then compile the reports, coordinate them and submit them to the participants for review; and then, by 20 March, agencies would have provided their comments by telephone so that he could report to NERBC on that date.

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# EROSION STUDY MEETING

31 January 1974

## AGENDA

10:00 a.m.

- I. INTRODUCTIONS
- II. SCOPE OF THE STUDY AND THE STUDY AREA
- III. SCHEDULING AND REPORTING
- IV. EROSION IN GENERAL
- V. INFORMATION EXCHANGE  
(Since the study is to be carried out in one month, it is important to make as much information as possible available to all study participants at the onset of the study. Therefore, everybody is asked to contribute whatever information they have pertinent to the erosion problem at the three hydro pools).
- VI. CONCLUSIONS - ADJOURN

Meeting 31 January 1974

## CONNECTICUT RIVER EROSION STUDY

### Attendance

<u>Name</u>	<u>Organization</u>
John H. Mason	NED, Corps of Engineers
Larry Bergen	NED, Corps of Engineers
Hank Baker	NED, Corps of Engineers
John Smith	NED, Corps of Engineers
Bob Wernecke	Vermont
James Minnoch	New Hampshire
George Morrison	New Hampshire Fish & Game
Edward Plumley	New England Power Company
Armand Milette	New England Power Company
Howard Stockwell	New England Power Company
Dave Campbell	New England Power Company
Milt Anderson	New England Power Company
Larry Dingman	✕ New England River Basins Commission
Jane Brower	Connecticut River Supplemental Study Science Advisory Group
James Kohler	Environmental Protection Agency
Raymond Grob	Federal Power Commission
Peg Kohl	U. S. Bureau of Sport Fishery & Wildlife
Keith MacPherson	Soil Conservation Service

CONNECTICUT RIVER BANK EROSION STUDY

REPORT FINALIZATION MEETING

WALTHAM, MASSACHUSETTS - 18 APRIL 1974

ATTENDANCE LIST

John T. Smith, Corps of Engineers, Chairman

Milton A. Anderson, New England Power Company

Jane V. Brower, New England River Basins Commission, Science  
Advisory Group

David R. Campbell, New England Power Company

S. Lawrence Dingman, New England River Basins Commission

John C. Hart, Corps of Engineers

Martin Inwald, Federal Power Commission

Margaret A. Kohl, U. S. Bureau of Sport Fisheries & Wildlife

James A. Kohler, U. S. Environmental Protection Agency

Keith MacPherson, U. S. Soil Conservation Service

George R. Morrison, New Hampshire Fish and Game

Edward A. Plumley, New England Power Company

Howard E. Stockwell, New England Power Company

Robert Wernecke, Vermont Department of Water Resources



**BANK EROSION STUDY**  
**CONNECTICUT RIVER**  
**NEW HAMPSHIRE & VERMONT**

UNITED STATES  
DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

FEBRUARY 1974

BANK EROSION STUDY  
CONNECTICUT RIVER

This report summarizes information on the extent of significant bank erosion along the 95 mile reach of the Connecticut River between Vernon Dam and the headwaters of the power pool at Wilder Dam.

The information presented was provided by the Soil Conservation Service personnel from each of the 6 counties abutting the reach of river under consideration. The information shows that portion of the river, located between Vernon Dam on the south and Woodsville, New Hampshire, on the north, which has a total length of 51 miles of eroded river bank. Of this total 28 miles of eroding bank are on the easterly, or New Hampshire, side of the river. The remaining 23 miles are located on the westerly, or Vermont side.

The data submitted was obtained from field reconnaissance surveys, measurements from aerial photographs, field surveys, and interviews with landowners. The data is varied in both amount and degree of detail because of the availability of personnel to gather the data within the limited time. Weather and snow cover also hindered the gathering of data to some extent. Summaries of the data received from each of the six counties follows:

Cheshire County, New Hampshire:

Cheshire County has approximately 35 miles of frontage on the Connecticut River north of Vernon Dam. Of this total the 7 miles between Vernon Dam and the Route 9 crossing has little or no bank erosion. The remaining 28 miles to the north of Route 9 has 20 areas of significant bank erosion ranging from 200 to 6350 feet in length and from 2 to 30 feet in height. The location of each of these areas is shown on Exhibits 1-1 through 1-3. Detailed information pertaining to the length, height, and type of soil for each section of the eroded bank is contained in Table 1. Soil Survey Interpretations for each soil type are shown in Exhibits 3-1, 3-3 and 3-4.

With the exception of Location No. 12, no dimensions for the depth of bank lost were included in the data from Cheshire County. The information did show that 10 to 15 feet of bank has been lost at Location No. 12 over a period of 17 years. Based on these dimensions and the height and length of bank shown in Table 1 for this location, the estimated losses in both volume of soil and area, ranges from 1925 c.y. and 0.02 acres to 2890 c.y. and 0.03 acres. The degree of change that has taken place over the 17 year period is illustrated by the photographs in Exhibit 2-1.

Sullivan County, New Hampshire:

Reconnaissance of the 36 miles of the Connecticut River located within the boundaries of Sullivan County shows that approximately 59,400 feet or approximately 11 miles of river bank are eroding to some degree.

The most severe erosion is occurring south of Route 103 at locations 21 through 28. At these locations the banks are vertical or nearly vertical as illustrated in Exhibit 4-1 and range from 4 to 40 feet in height.

Although annual losses for the eroding areas in this reach range from minimum values of 1 to 2 feet up to maximum values of 5 to 7 feet, losses up to 15 feet are not uncommon. One farmer reported that he lost 7 rows of corn plus a buffer strip adjacent to the edge of the bank this past year.

North of Route 103 the erosion is not as apparent, nor is it as severe at Locations 29, 31, 34 and 35 where the banks are vertical or nearly vertical. This may be in part due to the fact that the banks at Locations 30, 32, 33 and 36 through 37 slope into the channel as illustrated in Exhibit 5-1. Better vegetative cover may also contribute to the reduced erosion north of the Route 103.

The locations of the areas of eroding river bank within the boundaries of Sullivan County are shown on Exhibits 1-3, 1-4, and 1-5. Table 2 shows the dimensions eroding bank at each location. It also shows the volume of material and area lost annually as well as the type of soil for each location. Soil Survey Interpretations for each soil type are shown in Exhibits 3-1, 3-3, 3-4, 3-6, and 3-16.

#### Grafton County, New Hampshire

Reconnaissance of the 52 miles of the Connecticut River between the Sullivan-Grafton County line and Howards Island shows that at 49 locations severe bank erosion is taking place. The total length of eroded bank is 52,900 feet, or approximately 10 miles. In addition to these severely eroding areas, numerous raw areas dot the bank. No attempt was made to tally these areas as they are characteristic of almost the entire river bank. The severely eroded areas are located by number on Exhibits 1-5 through 1-8.

Table 3 shows the length, the average height, the soil type, and the soil description for each location. Exhibits 3-1 through 3-5, 3-7, 3-13 through 3-16, provide the Soil Survey Interpretations for the types of soils.

The following comments, for the eroded areas indicated, were also included with the information from Grafton County:

<u>Location No.</u>	<u>Remarks</u>
40-46	Wooded area
47, 49, 50	Wooded area
48	Below CRREL, may have started from gravel operation at top edge of slope
51	Half wooded, half hayland
52	Hayland and 15 year old Christmas tree plantation
53	Town road has been threatened and undermined
54	Recreation area with lawn to river bank, one small gully
55-57	Banks covered with ice - information from owner
58	Wooded
59	Includes small gully on area repaired 5 years ago
60, 61	Hayland
63	2 to 3 acres has been lost over the past 5 years
64	Residential land use
65, 67	Hayland

<u>Location No.</u>	<u>Remarks</u>
68	Pasture
69	Hayland, one small gully has been repaired.
* 71	Semi-eroded hayland bordered by large trees on river bank, large crack located 2 to 8 feet back from the edge of the bank runs almost the entire length of the field. This crack was evident before 1973 flooding
72	Pasture and wooded area
73	Hayland
* 74	Conditions similar to those at Location 71
75	River almost cut off an old oxbow leaving an island - 2-3 acres lost
76	Hayland, severely eroded, lost 2 acres prior to 1973 floods
77	Pasture
78	Hayland
79	Lost about 40,000 c.y. of soil during June flood. Severe erosion due to heavy overgrazing
80	Hayland
81	Wooded
82	Hayland
83	Pasture
84	Crops and hay
86	Corn
87	Heavy hardwood trees along top of bank - top is severely cracked
89	Small gully needs repair - river bank has eroded again.

\* Using the lengths and heights of eroded bank, for locations 71 and 74, from Table 3, and the distances from the edge of bank to the cracks shown above, the potential losses of volumes of material and areas range from 1850 c.y. and 0.11 acres to 7410 c.y. and 0.46 acres for Location 71 and from 1260 c.y. and 0.08 acres to 5040 c.y. and 0.31 acres for Location 74.

#### Windham County, Vermont

Windham County has approximately 40 miles of frontage on the Connecticut River between Vernon Dam and the Windham-Windsor County line. Although the information furnished did not include any estimate of the depth of bank, the volume of material or the areas lost for any specific locations, it did show that there is a total length of 21,400 feet or approximately 4 miles of 10 to 15 feet high bank showing signs of significant erosion. (Exhibits 1-1, 1-2, and 1-3.) Soil Survey Interpretations for the Agawam and Hadley soils found in this reach are shown in Exhibits 3-1, 3-3 and 3-4.

#### Windsor County, Vermont

Reconnaissance of the 45 miles of the Connecticut River bank located within the boundaries of Windsor County, shows approximately 75,900 feet, or approximately 14 miles of eroding bank. Individual areas, within this 75,900 feet, range from 660 to 6600 in length and from 2.5 to 25 feet in average height.

As shown by Table 4 the information on lengths of eroding bank is classified by both average height and type of soil on a town by town basis. Although the specific areas of bank erosion cannot be pinpointed on Exhibits 1-3 through 1-7 the locations are separated by towns. The range of annual loss of depth of bank, volume of material, and area for each segment of eroding bank, are also shown in Table 4.

#### Orange County, Vermont

Reconnaissance of the 38.5 miles of the Connecticut River located to the north of the Windsor-Orange County line shows that severe bank erosion is taking place at 28 Locations. The total length of eroded bank is 26,250 feet or approximately 5 miles.

The information furnished included length of bank, average height of bank, area lost annually, and the type of soil for each location. Table 5 shows this information plus the computed depth of bank loss annually. The depth of bank lost for each location was determined from the length of eroded bank and area lost for each location.

The location of each section of eroded bank is shown on Exhibits 1-7 and 1-8. The Soil Survey Interpretations for the soil types are shown in Exhibits 3-1, 3-3 and 3-4

Three of the reporting counties had common comments in their reports. Each county reported that banks having large trees growing either on the face or along the top of the bank appear to be more susceptible to erosion than those with grass, brush, small trees.

Each county reported numerous instances of gouging, of steeply sloping banks, by ice cakes. One county reported the personnel had observed ice cakes gouging up to 10 feet into the river banks. They also reported numerous instances of bank failure after large clods of frozen soil removed when cakes of anchor ice broke away from the banks, as illustrated in Exhibit 6.

## TABLE - I

# CONNECTICUT RIVER BANK EROSION STUDY

Cheshire County, New Hampshire

[illegible]

TABLE 2 - CONNECTICUT RIVER BANK EROSION STUDY

SULLIVAN COUNTY, NEW HAMPSHIRE

Location	Slope of Bank	Length of Bank Ft	Average Height of Bank Ft	Approximate Depth of Bank Lost Per Year From Ft To Ft	Approximate Volume Lost Per Year From C.Y. To C.Y.	Approximate Area Lost Per Year From Ac To Ac	Soil Type	Soil Description						
21	Vertical	3,900	7	3 5	3,030 5,060	0.27 0.45	Hadley & Windoski	v. f. s. l.						
22	Vertical	3,300	10	3 5	3,670 6,110	0.23 0.38	Hadley	v. f. s. l.						
23	Vertical	1,900	4	3 5	840 1,410	0.13 0.22	Hadley	v. f. s. l.						
		4,700	18	5 7	15,670 21,930	0.54 0.76	Hadley	v. f. s. l.						
		6,600			16,510 23,340	0.67 0.98								
24	Vertical	4,000	4	2 4	1,190 2,370	0.18 0.37	Hadley	v. f. s. l.						
25	Vertical	1,300	40	1 3	1,925 5,780	0.03 0.09	Hadley & Agawam	v. f. s. l.						
		2,600	15	3 5	4,330 7,220	0.18 0.30	Hadley & Agawam	v. f. s. l.						
		900	20	1 3	670 2,000	0.02 0.06	Hadley & Agawam	v. f. s. l.						
		4,800			6,925 15,000	0.23 0.45								
26	Vertical	2,400	20	2 4	3,560 7,110	0.11 0.22	Hadley	v. f. s. l.						
		3,000	15	2 4	3,330 6,670	0.14 0.28	Hadley	v. f. s. l.						
		5,400			6,890 13,780	0.27 0.50								
27	Vertical	1,700	20	1 3	1,260 3,780	0.04 0.12	Hadley	v. f. s. l.						
		1,800	20	3 5	4,000 6,670	0.12 0.21	Hadley	v. f. s. l.						
		2,200	15	1 2	1,330 2,660	0.05 0.10	Hadley	v. f. s. l.						
		5,700			6,590 13,110	0.21 0.43								
28	Vertical	3,000	8	1 3	890 2,670	0.07 0.21	Hadley	v. f. s. l.						
		1,100	18	3 5	2,200 3,670	0.21 0.34	Hadley	v. f. s. l.						
		4,100			3,090 6,340	0.28 0.55								

TABLE 2 - CONNECTICUT RIVER BANK EROSION STUDY

SULLIVAN COUNTY, NEW HAMPSHIRE

Location	Slope of Bank	Length of Bank Ft	Average Height of Bank Ft	Approximate Depth of Bank Lost Per Year From To Ft Ft	Approximate Volume Lost Per Year From To C.Y. C.Y.	Approximate Area Lost Per Year From To Ac Ac	Soil Type	Soil Description				
29	Vertical	1,600	20	1 2	1,185 2,370	0.04 0.07	Hadley	v.f.s.l.				
30	Sloping	1,300				0.04 0.15	Hadley	v.f.s.l.				
31	Vertical	2,000	50	1 2	3,705 7,410	0.05 0.09	Hadley	v.f.s.l.				
32	Sloping	1,500		VERY MINOR EROSION			Hadley	v.f.s.l.				
33	Sloping	2,500		VERY MINOR EROSION			Hadley, Winnski & Limbrick	v.f.s.l. s.l.				
34	Vertical	3,300	10	1 2	1,220 2,445	0.08 0.15	Hadley	v.f.s.l.				
35	Vertical	2,000	15	1 2	1,110 2,220	0.05 0.10	Hadley	v.f.s.l.				
36	Sloping	3,300				0.04 0.08	Hadley	v.f.s.l.				
37	Sloping	1,300		VERY MINOR EROSION			Hadley	v.f.s.l.				
38	Sloping	1,000		VERY MINOR EROSION			Hadley	v.f.s.l.				
39	Sloping	1,800		VERY MINOR EROSION			Hadley	v.f.s.l.				
Total length of Sloping Bank				12,700 Ft						VOLUME		AREA
Total length of Vertical Bank				46,700 Ft						From	To	From To
Total length of Bank Studied				59,400 Ft						C.Y.	C.Y.	Ac Ac
Total length of sloping Bank with significant Erosion				4,600 Ft			Totals lost from Sloping Banks with significant Erosion			—	—	0.08 0.23
Total length of vertical bank with significant Erosion				46,700 Ft			Totals lost from Vertical Banks with significant Erosion			53,115	99,555	2.56 4.52
Total length of Bank with significant Erosion				51,300 Ft			Totals lost from banks with significant Erosion					2.64 4.75



TABLE 3

## CONNECTICUT RIVER BANK EROSION STUDY

## GRAFTON COUNTY, NEW HAMPSHIRE

Location No.	Length of eroded Bank Ft.	Average Height of Eroded Bank Ft.	SOIL TYPE	Soil Description			
40-46	1800	25	40-42 Hartland 43-46 Windsor	V.F.S.L. L.S.			
47, 49, 50	1800	19	Windsor	L.S.			
48	100	42	Windsor	L.S.			
51	1800	19	Windsor	L.S.			
52	2600	12	Hadley	V.F.L.S.			
53	1000	8	Hartland	V.F.L.S.			
54	500	5	Hadley	V.F.L.S.			
55-57	3000	8	Hadley & Suncook & Colton	V.F.L.S. & L.S. & G.L.S.			
58	300	6	Windsor	L.S.			
59-60	3,500	6	Hadley & Suncook	V.F.L.S. L.S.			
61	600	9	Hadley	V.F.L.S.			
62	1,500	25	Hadley	V.F.L.S.			
63, 64	900	18	Agawam	V.F.L.S.			
65	1,500	5	Hadley	V.F.L.S.			

TABLE 3

## CONNECTICUT RIVER BANK EROSION STUDY

## GRAFTON COUNTY, NEW HAMPSHIRE

Location No.	Length of Eroded Bank Ft.	Average Height of Eroded Bank Ft.	Soil Type	Soil Description			
66	100	20	Hadley	V.F.S.L.			
67	9,800	14	Hadley	V.F.S.L.			
68	2,500	14	Hadley	V.F.S.L.			
69	1,400	8	Hadley	V.F.S.L.			
70	2 GULLIES ON UNDERHILL FARM		Hadley	V.F.S.L.			
71	2,500	10	Suncook & Hadley	S.L. & V.F.S.L.			
72	400	7	Suncook	S.L.			
73	1,000	10	Hadley	V.F.S.L.			
74	1,700	10	Hadley	V.F.S.L.			
75	2,500	15	Hadley	V.F.S.L.			
76	2,500	25	Hadley	V.F.S.L.			
77	500	10	Hadley	V.F.S.L.			
78	800	10	Hadley	V.F.S.L.			
79	2,200	21	Suncook & Hadley	S.L. & V.F.S.L.			

CONNECTICUT RIVER BANK EROSION STUDY  
GRAFTON COUNTY, NEW HAMPSHIRE

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TABLE 4 - CONNECTICUT RIVER BANK EROSION STUDY

WINDSOR COUNTY, VERMONT

Location	Length of Eroded Bank Ft	Average Height of Eroded Bank Ft	Approximate Depth of Bank Lost Per Year From To Ft Ft		Approximate Volume Lost Per Year From To Cu. Y. Cu. Y.		Approximate Area Lost Per Year From To Ac Ac		Soil Type	Soil Description						
91	3960	2.5	2	3	735	1100	0.18	0.27	Hadley	v.f.s.l.						
92	2640	2.5	2	3	490	735	0.12	0.18	Windsor	l.s.						
93	1980	7.5	2	3	1100	1650	0.09	0.14	Windsor	l.s.						
94	660	12.5	2	3	610	915	0.03	0.05	Windsor	l.s.						
	9240				2935	4400	0.42	0.64								
95	6600	2.5	2	3	1220	1835	0.30	0.45	Windsor	l.s.						
96	1320	7.5	2	3	735	1100	0.06	0.09	Hadley & Winooski	v.f.s.l.						
97	3960	7.5	2	3	2200	3300	0.18	0.27	Ondawa	s.l.						
98	1320	7.5	2	3	735	1100	0.06	0.09	Unadilla (Hartland)	s.l.						
99	1320	7.5	2	3	735	1100	0.06	0.09	Windsor	l.s.						
100	3300	12.5	2	3	3055	4585	0.15	0.23	Windsor	l.s.						
101	2640	17.5	2	3	3420	5135	0.12	0.18	Hadley	v.f.s.l.						
102	1320	2.5	2	3	2445	3665	0.06	0.09	Windsor	l.s.						
	21,780				14,545	21,820	0.99	1.49								
103	3300	2.5	2	3	610	915	0.15	0.23	Hadley	v.f.s.l.						
104	2640	2.5	2	3	490	735	0.12	0.18	Hadley	v.f.s.l.						
105	2640	2.5	2	3	490	735	0.12	0.18	Winooski	v.f.s.l.						
106	3960	2.5	2	3	735	1100	0.18	0.27	Made Land							
107	1320	7.5	2	3	735	1100	0.06	0.09	Podunk	f.s.l.						
	13,860				3060	4585	0.63	0.95								

TABLE 4

TABLE 4 - CONNECTICUT RIVER BANK EROSION STUDY

WINDSOR COUNTY, VERMONT

Location No.	Length of Eroded Bank Ft.	Average Height of Eroded Bank Ft.	Approximate depth of bank lost per year From To Ft. Ft.	Approximate Volume lost per year From To Cy. Cy.	Approximate Area lost per year From To Ac. Ac.	Soil Type	Soil Description								
108	1980	2.5	2 3	365 550	0.09 0.14	Windsor	L.S.								
109	1980	2.5	2 3	365 550	0.09 0.14	Ondawa	S.L.								
110	1320	2.5	2 3	245 365	0.06 0.09	Windsor	L.S.								
111	1320	7.5	2 3	735 1100	0.06 0.09	Windsor	L.S.								
112	1320	7.5	2 3	735 1100	0.06 0.09	Podunk	F.S.L.								
113	1320	12.5	2 3	1220 1835	0.06 0.09	Windsor	L.F.S.								
114	1320	12.5	2 3	1220 1835	0.06 0.09	Windsor	L.F.S.								
115	1980	17.5	2 3	2565 3850	0.09 0.14	Windsor	L.F.S.								
116	1320	2.5	2 3	2445 3665	0.06 0.09	Windsor	L.S.								
	13,860			9895 14,850	0.63 0.96										
117	1320	2.5	2 3	245 365	0.06 0.09	Hadley	V.F.S.L.								
118	3960	2.5	2 3	735 1100	0.18 0.27	Windsor	L.F.S.								
119	660	7.5	2 3	365 550	0.03 0.05	Windsor	L.F.S.								
120	660	7.5	2 3	365 550	0.03 0.05	Windsor	L.F.S.								
121	660	7.5	2 3	365 550	0.03 0.05	Windsor	L.F.S.								
122	660	12.5	2 3	610 915	0.03 0.05	Windsor	L.F.S.								
123	2460	17.5	2 3	3420 5135	0.12 0.18	Windsor	L.F.S.								
	10,560			6095 9165	0.48 0.74										
124	2460	2.5	2 3	490 735	0.12 0.18	Windsor	L.F.S.								
125	3300	7.5	2 3	1830 2750	0.15 0.23	Windsor	L.F.S.								
126	660	12.5	2 3	610 915	0.03 0.05	Windsor	L.F.S.								
	6600			2930 4400	0.30 0.46										
TOTAL	75,900			39,460 59,220	3.45 5.24										
	19.38 MILES														

TABLE 4

TABLE 5 - CONNECTICUT RIVER BANK EROSION STUDY

ORANGE COUNTY, VERMONT

Location	Length of Eroded Bank Ft	Average Height of Eroded Bank Ft	Approximate Depth of Bank Lost Per Year Ft	Approximate Volume Lost Per Year C.Y.	Approximate Area Lost Per Year From Ac To Ac	Soil Type	Soil Description							
127	500	10	4.3	805	0.05 0.25	Agawam	v.f.s.l.							
128	700	15	6.22	2420	0.1 0.5	Hadley	v.f.s.l.							
129	1000	15	2.18	1210	0.05 0.25	Agawam	v.f.s.l.							
130	100	10	8.71	325	0.02 0.10	Hadley	v.f.s.l.							
131	1600	10	4.08	2420	0.15 0.75	Hadley	v.f.s.l.							
132	600	10	7.26	1615	0.10 0.5	Hadley	v.f.s.l.							
133	750	15	11.62	4840	0.20 1.00	Hadley	v.f.s.l.							
134	600	10	3.63	805	0.05 0.25	Hadley	v.f.s.l.							
135	600	10	3.63	805	0.05 0.25	Hadley	v.f.s.l.							
136	1000	10	4.36	1615	0.10 0.50	Hadley	v.f.s.l.							
137	1000	15	4.36	2420	0.10 0.5	Hadley	v.f.s.l.							
138	2500	10	3.48	3225	0.2 1.00	Hadley	v.f.s.l.							
139	2500	10	3.48	3225	0.2 1.00	Hadley	v.f.s.l.							
140	200	5	4.36	160	0.02 0.1	Hadley	v.f.s.l.							
141	1000	25	4.36	4035	0.10 0.5	Agawam	v.f.s.l.							
142	800	15	5.44	2420	0.10 0.5	Hadley	v.f.s.l.							

TABLE 5

1999

ORANGE COUNTY, VERMONT

[illegible]

TABLE 5



UNITED STATES  
DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

BRATTLEBORO QUADRANGLE  
VERMONT-NEW HAMPSHIRE  
15 MINUTE SERIES (TOPOGRAPHIC)

(BELLOW FALLS)



See sht  
E-1

Maped, edited, and published by the Geological Survey  
Control by USGS and USCGS

Topography from aerial photographs by multiplex methods  
Aerial photographs taken 1951. Field check 1953 and 1954

Polyconic projection. 1927 North American datum  
10,000-foot grids based on Vermont and New Hampshire  
coordinate systems

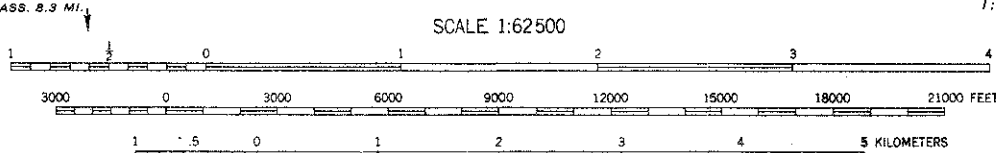
Red tint indicates area in which only  
and mark buildings are shown

Unchecked elevations are shown in brown

1000-meter Universal Transverse Mercator grid ticks,  
zone 18, shown in blue

TRUE NORTH  
MAGNETIC NORTH  
14°

APPROXIMATE MEAN  
DECLINATION, 1954



CONTOUR INTERVAL, 20 FEET  
DATUM IS MEAN SEA LEVEL



QUADRANGLE LOCATION

ROAD CLASSIFICATION

Heavy-duty ——— Light-duty ———  
Medium-duty ——— Unimproved dirt ———  
U.S. Route ——— State Route ———

BRATTLEBORO, VT.—N. H.  
N 4245—W 7230/15

1954

D-1

EXHIBIT 1-1

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS  
FOR SALE BY U. S. GEOLOGICAL SURVEY WASHINGTON 25, D. C.  
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

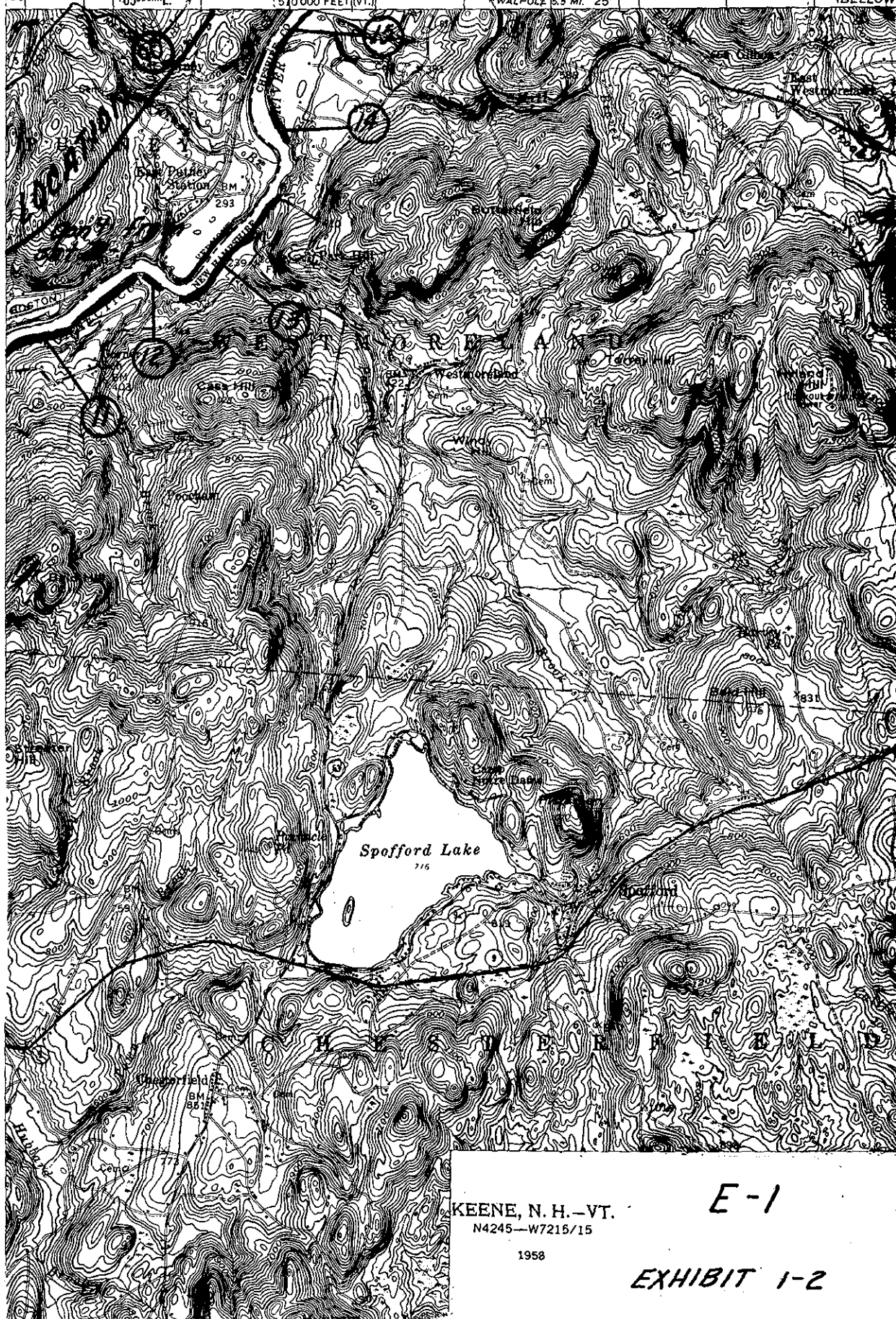


UNITED STATES  
DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY  
BELLWAS FALLS 10 MI. *see sht. E-2*  
30' 705000m.E. 1 510 000 FEET (VT.)

STATE OF NEW HAMPSHIRE  
HIGHWAY DEPARTMENT

BELLOWS FALLS, VT. 10 MI.  
WALPOLE 15.5 MI. 25' 1

(BELLOW



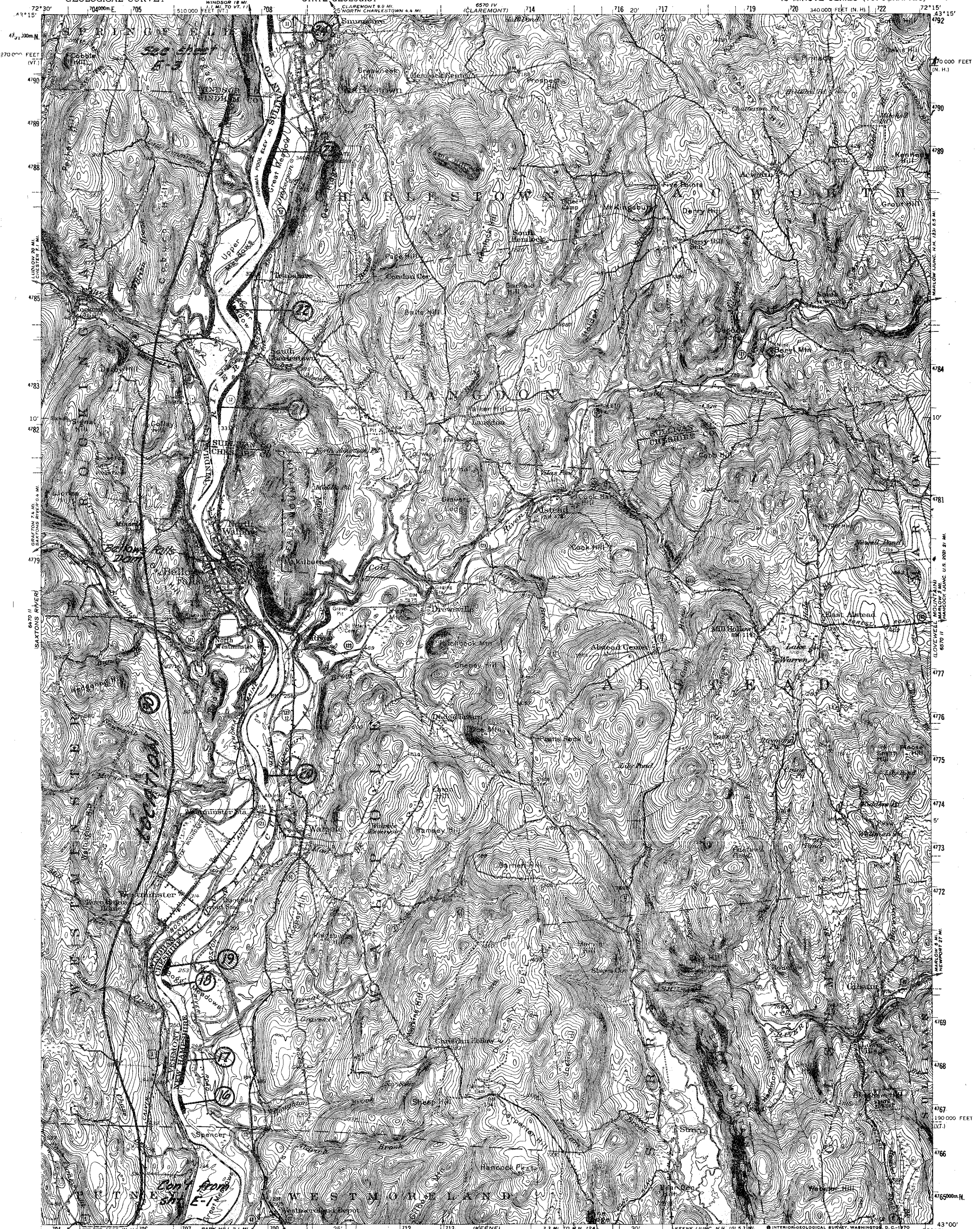
KEENE, N. H.—VT.  
N4245—W7215/15

1958

E-1

*EXHIBIT 1-2*





Control by USGS and USC&GS  
Culture and drainage in part compiled from aerial photographs  
Topography by planetable surveys 1927. Revised 1957  
Polyconic projection. 1927 North American datum  
10,000-foot grids based on New Hampshire and Vermont  
coordinate systems  
8,000-meter Universal Transverse Mercator grid ticks,  
zone 18, shown in blue  
Area covered by dashed light-blue pattern  
is subject to controlled inundation to 550 feet

UTM GRID AND 1957 MAGNETIC NORTH  
DECLINATION AT CENTER OF SHEET

SCALE 1:62,500  
CONTOUR INTERVAL 20 FEET  
DATUM IS MEAN SEA LEVEL

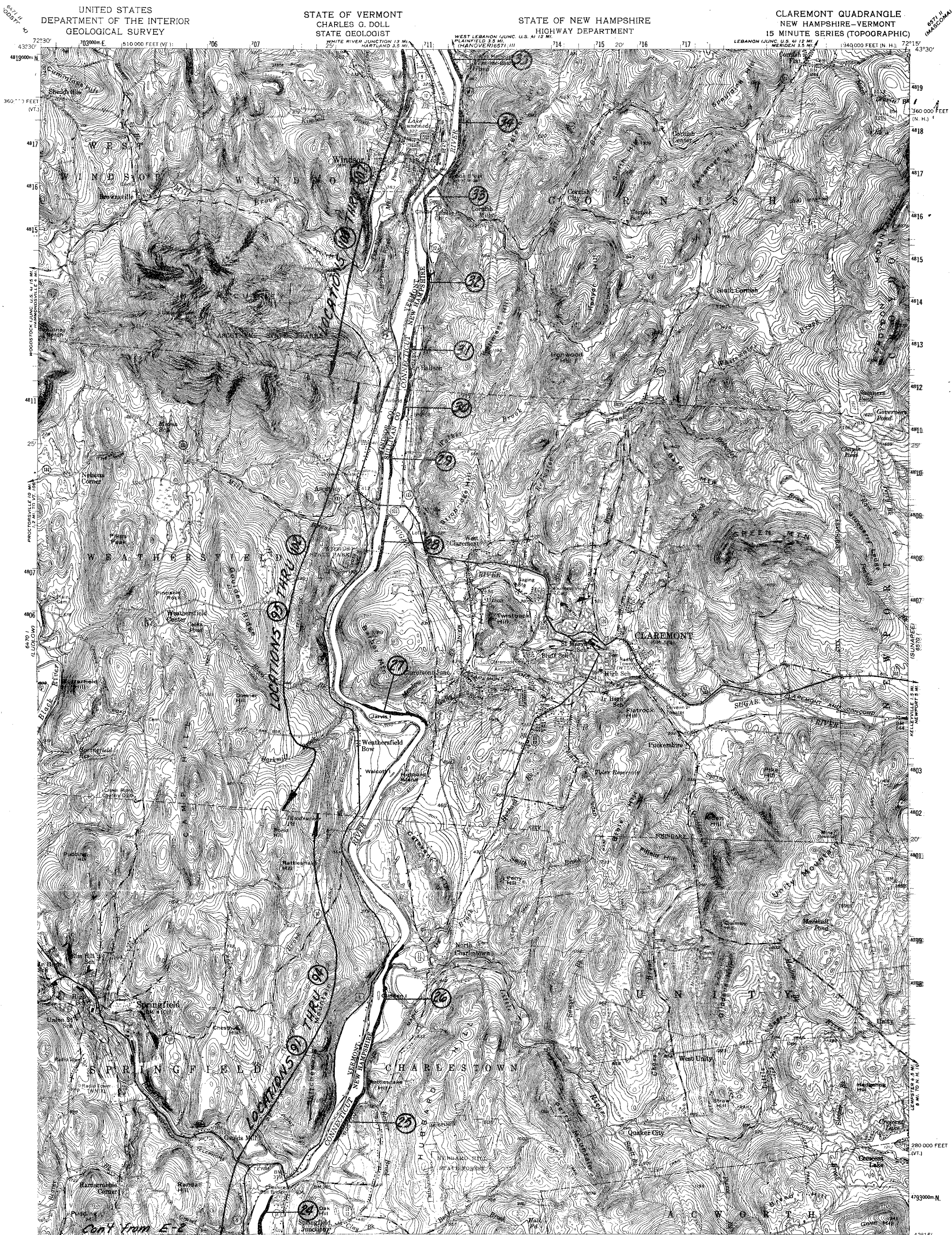
ROAD CLASSIFICATION  
Heavy-duty ——— Light-duty ———  
Medium-duty ——— Unimproved dirt ———  
U.S. Route ——— State Route ———

FOR SALE BY U.S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242  
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

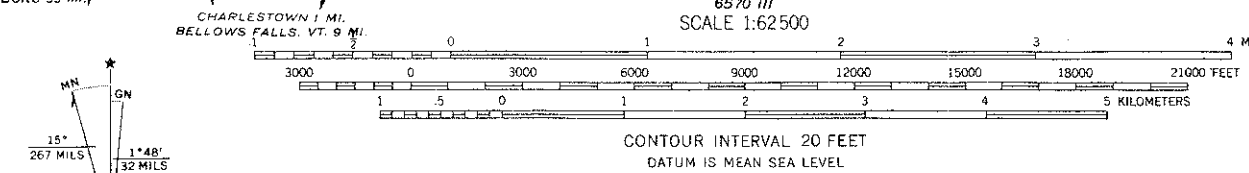
BELLOWS FALLS, N. H.-VT.  
N4300—W7215/15  
1957  
AMS 6570 III—SERIES V712

E-2  
EXHIBIT 1-3





Maped, edited, and published by the Geological Survey  
Control by USGS, USC&GS, and Vermont-New Hampshire  
Boundary Commission  
Culture and drainage in part compiled from aerial photographs  
Topography by planetable surveys 1926. Culture revised 1957  
Polyconic projection. 1927 North American datum  
10,000-foot grids based on New Hampshire coordinate  
system and Vermont coordinate system  
1000-meter Universal Transverse Mercator grid ticks,  
zone 18, shown in blue  
Area covered by dashed light-blue pattern is subject  
to controlled inundation to 545 feet  
Red tint indicates areas in which only  
landmark buildings are shown



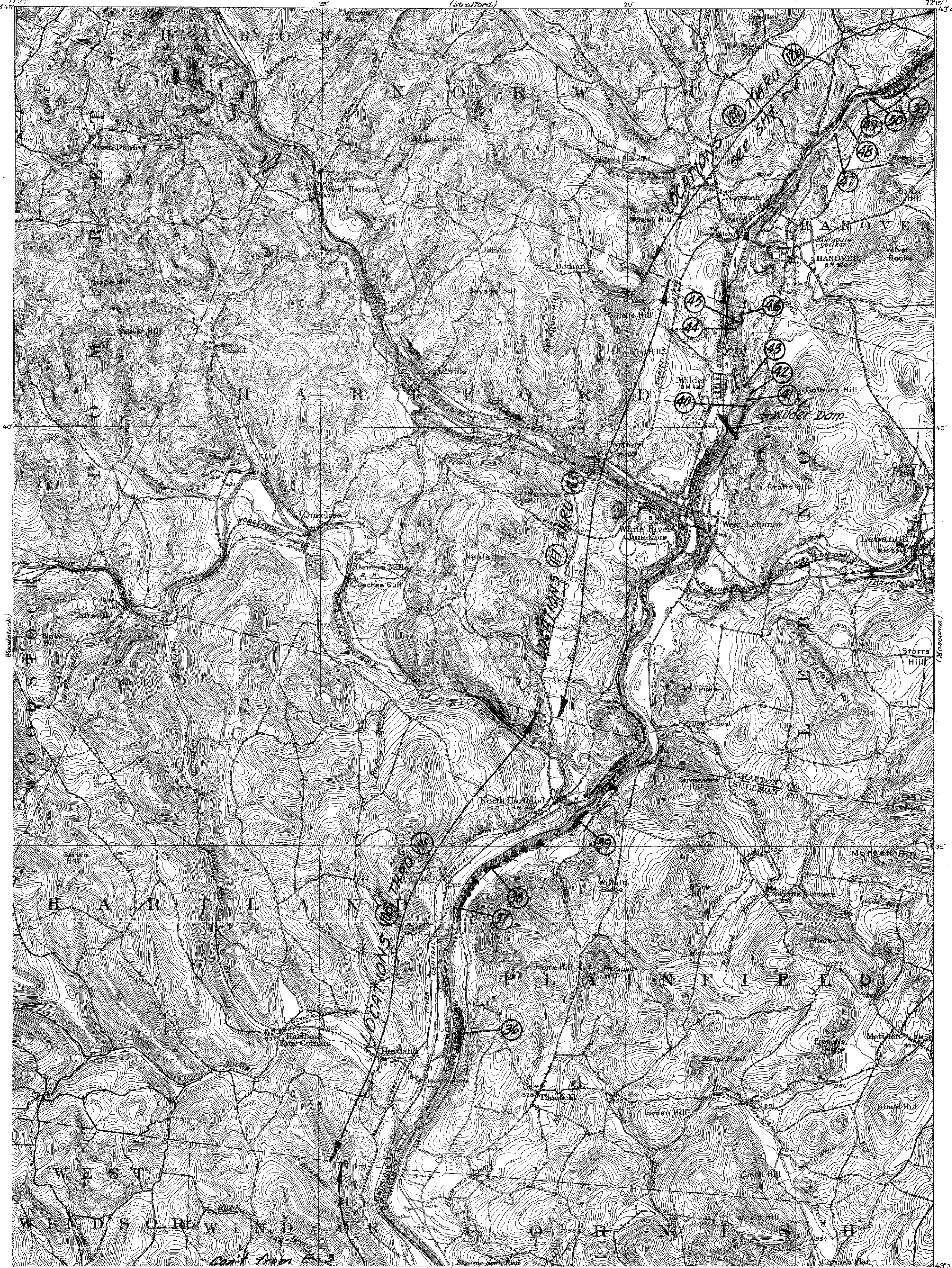
ROAD CLASSIFICATION  
Heavy duty ——— Light duty ———  
Medium duty ——— Unimproved dirt ———  
U. S. Route —○— State Route —○—

FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON 25, D. C.,  
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

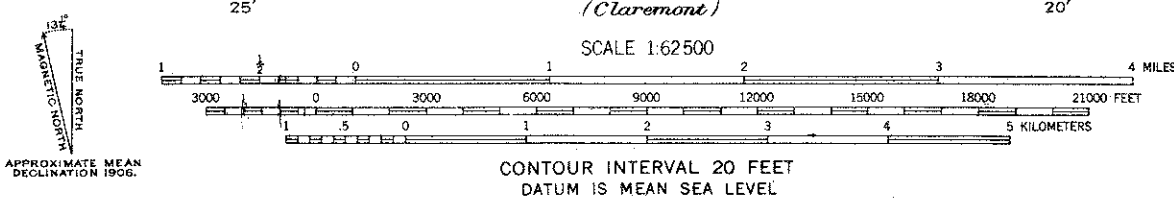
CLAREMONT, N. H.-VT.  
N4315-W7215/15  
1957  
AMS 6570 IV-SERIES V712

E-3  
EXHIBIT 1-4





H.M. Wilson, Geographer.  
J.H. Jennings, in charge of section.  
Topography by Chas. Hartmann, Jr. and L.C. Fletcher.  
Control by Coast and Geodetic Survey and W. Carvel Hall.  
Surveyed in 1905-1906.



Polyconic projection. 1927 North American datum.  
This area also covered by 7.5 minute  
1:24,000 scale maps: Hanover, Quechee,  
Hartland and North Hartland, surveyed 1959.

HANOVER, VT.-N.H.  
N4330-W7215/15  
1906

FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON 25, D. C.  
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

E-4

EXHIBIT 1-5



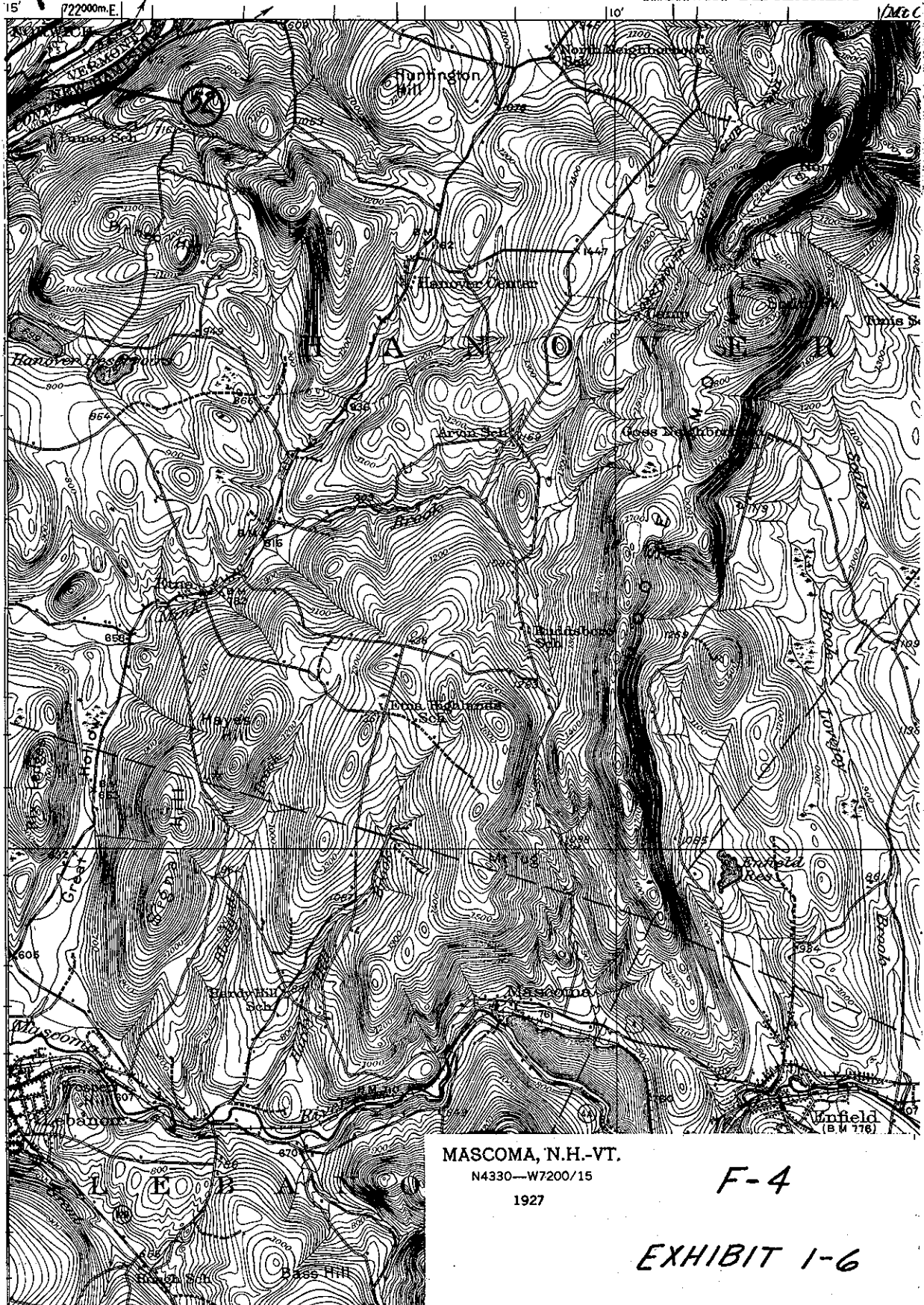
See Sht. F-5 Con't from E-4

BRADFORD 19 MI.  
EAST THETFORD 5 MI.

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

WOODSVILLE 34 MI.  
LYME 5 MI.

STATE OF NEW HAMPSHIRE  
HIGHWAY DEPARTMENT



MASCOMA, N.H.-VT.

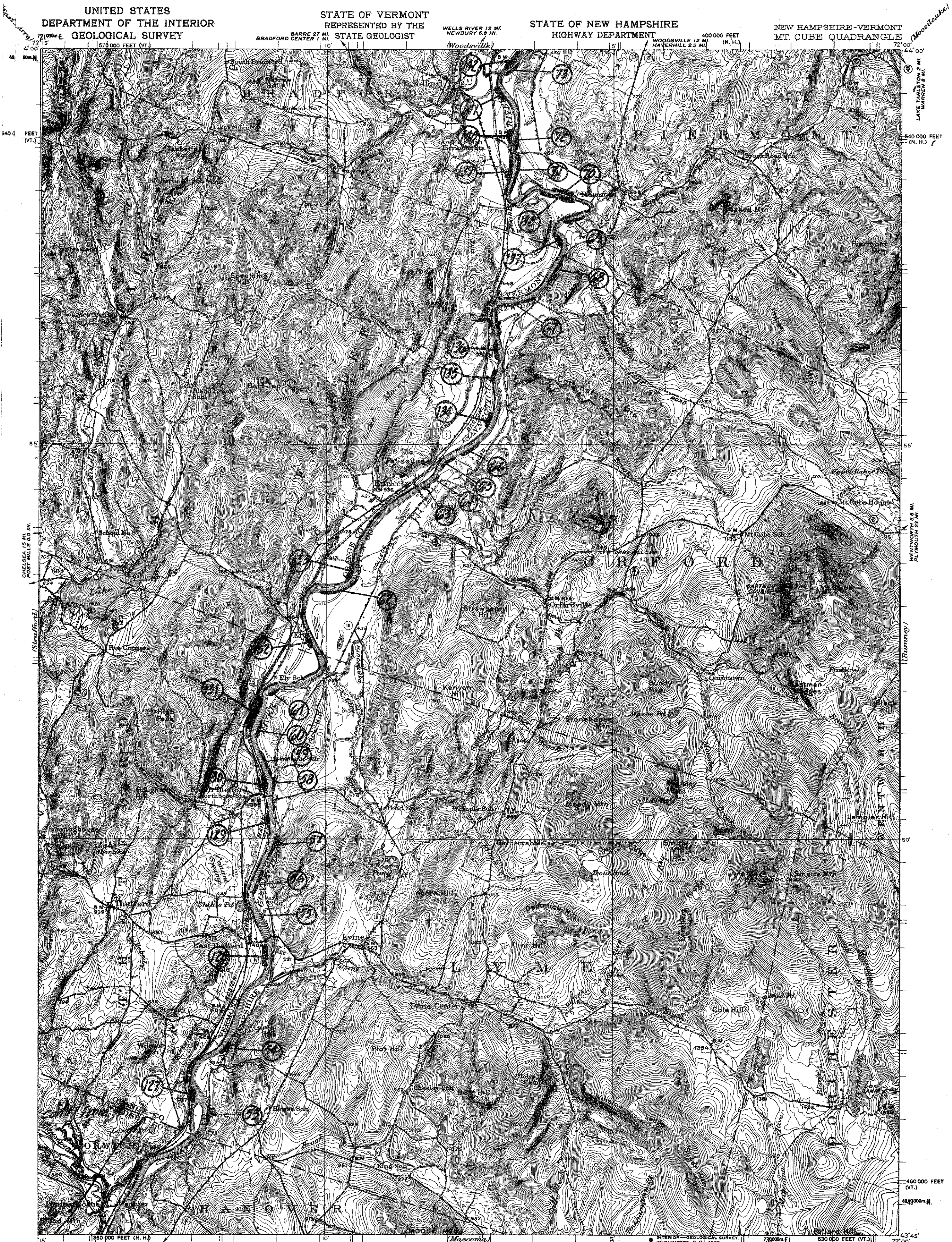
N4330—W7200/15

1927

F-4

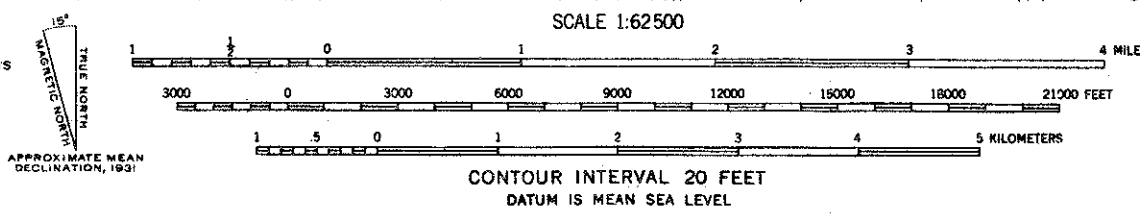
EXHIBIT 1-6





Topography by D.H. Watson, J.M. Whitman, H.A. Bean.  
W.F. Chénault and Paul Blake  
Culture and drainage in part compiled from aerial photographs  
taken by Air Corps U.S. Army  
Surveyed in 1929-1931

5 MI.  
CTION 10 MI. ROAD CLASSIFICATION  
Heavy-duty Light-duty  
Medium-duty Unimproved dirt  
U.S. Route State Route



FOR SALE BY U.S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242  
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

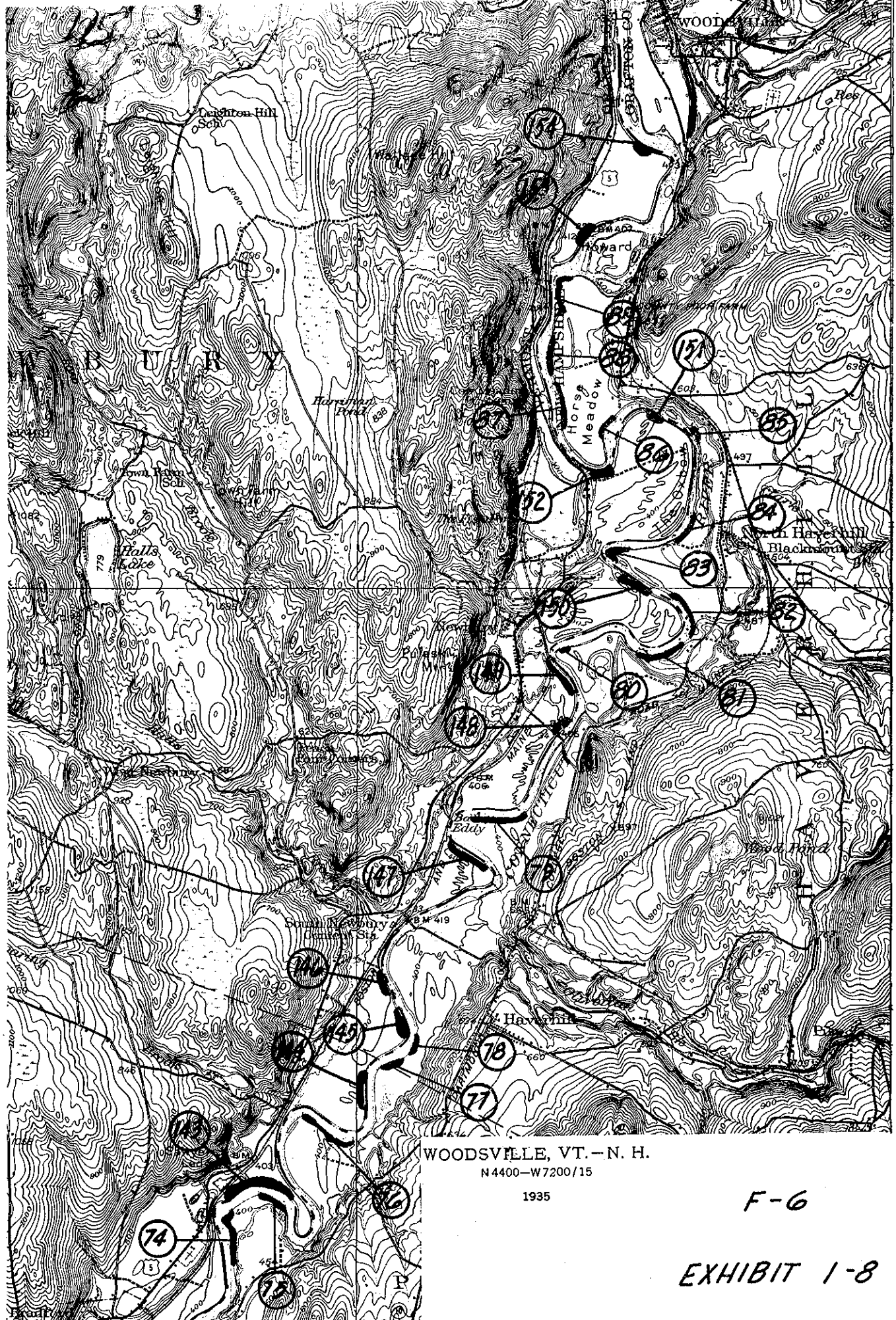
Polyconic projection. To place on 1927 North American datum  
move projection lines 50 feet north  
10,000 foot grid based on New Hampshire and Vermont  
rectangular coordinate systems  
1000-meter Universal Transverse Mercator grid ticks,  
zone 18, shown in blue

MT. CUBE, N.H.-VT.  
N 4345-W 7200/15  
1931

F-5

EXHIBIT 1-7





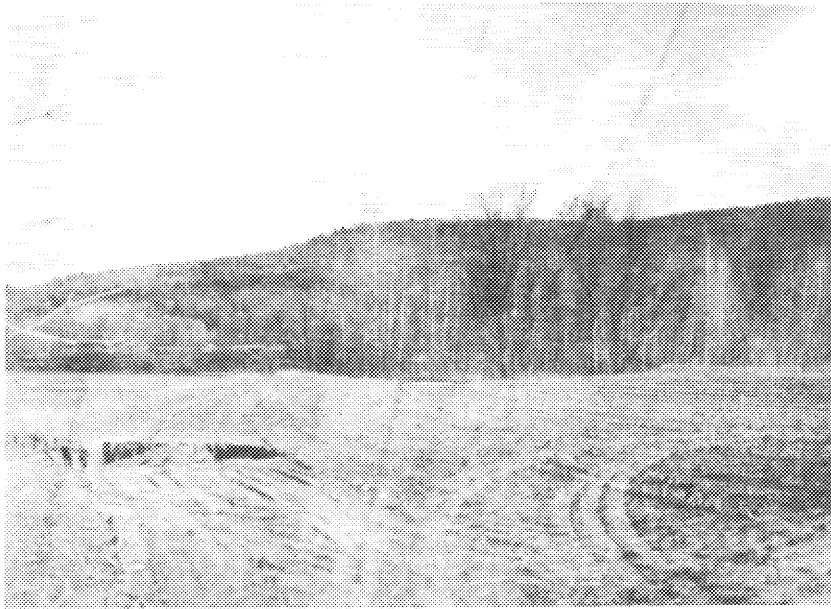
WOODSVILLE, VT. - N. H.

N 4400 - W 7200 / 15

1935

F-6

EXHIBIT 1-8



*1957*



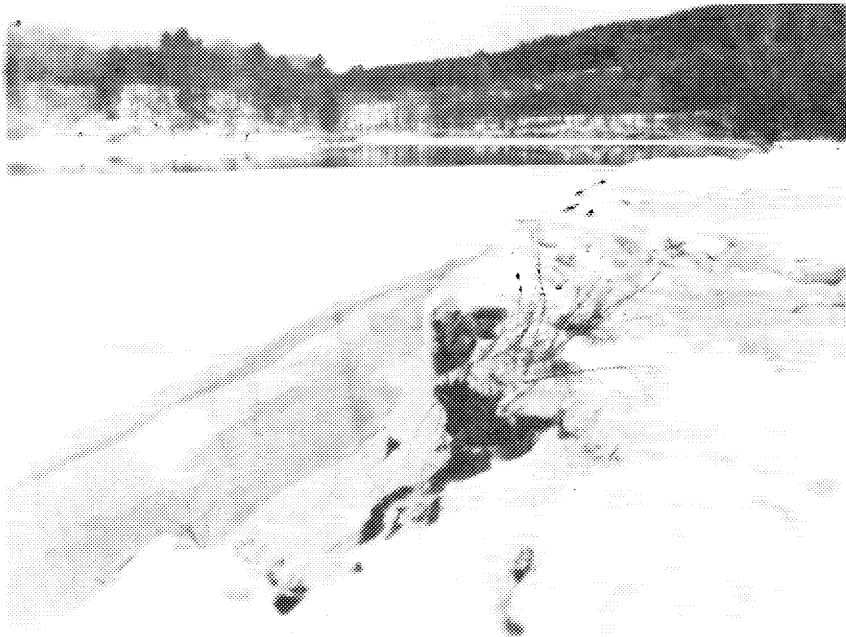
*2/13/74*

*LOCATION 12  
CHESHIRE COUNTY FARM  
WESTMORELAND, NEW HAMPSHIRE*

*EXHIBIT 2-1*



*LOCATION 12  
CHESHIRE COUNTY FARM  
WESTMORELAND, NEW HAMPSHIRE*



*2/13/74*

*EXHIBIT 2-1*

# SOIL SURVEY INTERPRETATIONS

SOIL: Arwam very fine sandy loam

STATE: New Hampshire

MAP SYMBOL(S): 24

DATE: 7-73

## BRIEF SOIL DESCRIPTION:

MLRA(S): 143, 144

These are well-drained soils that formed in thick deposits of sands. Typically they have a very dark grayish-brown very fine sandy loam surface soil 10 inches thick. The subsoil is yellowish-brown fine sandy loam 15 inches thick. The underlying material to a depth of 42 inches is light olive brown loamy fine sand and olive fine sand. These soils are mainly on outwash plains and stream terraces. Slopes range from 0 to 15 percent.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No.			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0-15	vfs1, fs1	SM, ML	A-4	95-100	90-100	45-65	2.0-6.0	.13-.25	5.0-6.5	Low
15-25	fs1, vfs1	SM, ML	A-4	95-100	90-100	40-55	2.0-6.0	.11-2.0	5.0-6.0	Low
25-42	lfs, fs, s	SM SP-SM	A-2	90-100	85-100	10-35	6.0	.02-.11	5.0-6.0	Very Low

Depth to Bedrock (Ft): 6-8+

Depth to Fragipan (Ft):       

Depth to Seasonal High Water Table (Ft): 6+

Flood Hazard: None

Potential Frost Action: Low

Hydrologic Group: B

## SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Poor: <sup>1/</sup> excess fines
Gravel	Poor: excess fines
Roadfill	Fair: excess fines
Daily Cover For Landfill	Good

## MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Cut slopes unstable, erodible
Pond Reservoir Areas	Moderately rapid permeability
Pond Embankments	Moderate permeability, subject to piping, erodible
Sprinkler Irrigation	High available water capacity
Drainage	2/
Diversions and Waterways	Moderately rapid permeability, high available water capacity, erodible

## DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	A & B C	Slight Moderate	Slope
Sewage Lagoon	A & B C	Severe Severe	Moderately rapid permeability Moderately rapid permeability, slope
Dwellings (With Basements)	A & B C	Slight Moderate	Slope
Dwellings (Without Basements)	A & B C	Slight Moderate	Slope
Lawns and Landscaping	A & B C	Slight Moderate	Slope
Local Roads, Streets and Parking Lots	A B C	Slight Moderate Severe	Slope Slope
Shallow Excavations (6 feet or less)	A & B C	Slight Moderate	Slope

United States Department of Agriculture  
Soil Conservation Service in Cooperation With  
New Hampshire Agricultural Experiment Station

Advance Copy - Subject to Change

1/ Fair below about 2 feet

2/ Practice generally not applied

EXHIBIT 3-1

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use		Slope		Degree of Limitation		Major Soil Feature(s) Affecting Use					
Camp Areas (Tent and Camp Trailers)		A & B C		Slight Moderate		Slope					
Picnic Areas (Park-Type)		A & B C		Slight Moderate		Slope					
Playgrounds (Athletic Fields)		A B C		Slight Moderate Severe		Slope Slope					
Paths and Trails (Hiking and Bridle)		A, B & C		Slight							
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Truck Crops		A & B C		Good Fair		Slope					
Field Crops		A & B C		Good Fair		Slope					
Hay and Pasture Crops		A, B & C		Good							
Apple Orchards		NOT RATED									
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to - - -						Productivity			Species to Favor - -	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restric- tions	Suit- ability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
All	Slight	Slight	Moderate	Slight	Slight	Slight	402	White Pine Red Oak Red Pine Northern Hardwoods	60-70 55-65 60-70 52-59	W.P. R.O. R.P. W.A. S.M.	W.P. R.P. W.S.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Openland		All		Good							
Woodland		All		Good							
Wetland		All		Very Poor		No water					

\* Indicator Species

# SOIL SURVEY INTERPRETATIONS

SOIL: Colton gravelly loamy sand

MAP SYMBOL(S): 622

BRIEF SOIL DESCRIPTION:

STATE: New Hampshire

DATE: 7-73

MLRA(S): 143, 144

These are excessively drained soils that formed in thick sand and gravel deposits. Typically these soils have a very dark grayish-brown gravelly loamy sand surface layer 7 inches thick over a gray leached gravelly loamy sand layer about an inch thick. The subsoil to 16 inches is dark reddish-brown and reddish-brown gravelly loamy sand. Below this to 50 inches is yellowish-brown and pale brown very gravelly sand. These soils generally occupy kames, eskers, and terrace breaks. Slopes range from 15 to more than 45 percent.

## ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING

Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0-16	gls	SM, SP-SM	A-1 A-2	65-75	55-70	10-30	>6.0	.05-.08	5.0	Very Low
16-50	vgs, vgcas, gcas	SP, SP-SM GP, GP-GM	A-1	35-55	25-50	0-10	>6.0	.01-.05	4.5-6.0	Very Low

Depth to Bedrock (Ft): 6-8+

Depth to Fragipan (Ft): \_\_\_\_\_

Depth to Seasonal High Water Table (Ft): 5+

Flood Hazard: None

Potential Frost Action: Low

Hydrologic Group: A

## SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Poor: coarse fragments
Sand	Good
Gravel	Good
Roadfill	Good
Daily Cover For Landfill	Poor: coarse fragments, slope

## MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Cut slopes unstable, slope
Pond Reservoir Areas	Rapid permeability, slope
Pond Embankments	Rapid permeability, slope
Sprinkler Irrigation	Very low available water capacity, slope
Drainage	1/
Diversions and Waterways	Rapid permeability, very low available water capacity, slope

## DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	A11	Severe 2/	Slope
Sewage Lagoon	A11	Severe 2/	Rapid permeability, slope
Dwellings (With Basements)	A11	Severe	Slope
Dwellings (Without Basements)	A11	Severe	Slope
Lawns and Landscaping	A11	Severe	Sandy and gravelly, slope
Local Roads, Streets and Parking Lots	A11	Severe	Slope
Shallow Excavations (6 feet or less)	A11	Severe	Poor sidewall stability, slope

United States Department of Agriculture  
Soil Conservation Service in Cooperation With  
New Hampshire Agricultural Experiment Station

Advance Copy - Subject to Change

1/ Practice generally not applied.

2/ Potential pollution hazard to nearby wells, streams and lakes.

EXHIBIT 3-2

Colton gravelly loamy sand

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use								
Camp Areas (Tent and Camp Trailers)	All	Severe	Slope								
Picnic Areas (Park-Type)	All	Severe	Slope								
Playgrounds (Athletic Fields)	All	Severe	Slope								
Paths and Trails (Hiking and Bridle)	All	Severe	Slope								
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use	Slope	Suitability	Major Soil Feature(s) Affecting Use								
Truck Crops	All	Unsuited	Droughty, slope								
Field Crops	All	Unsuited	Droughty, slope								
Hay and Pasture Crops	All	Unsuited	Droughty, slope								
Apple Orchards	All	Unsuited	Droughty, slope								
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to ~ ~ ~						Productivity			Species to Favor ~ ~	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
D & E	Moderate	Slight	Slight	Slight	Slight	Slight	4sl	White Pine Red Pine Red spruce Northern Hardwood	60-70 60-70 30-40 52-59	W.P. R.P. R.S. S.M. Y.B	W.P. R.P.
F	Moderate	Slight	Slight	Slight	Moderate	Severe	4sl				
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use								
Openland	All	Poor	Droughty, slope								
Woodland	All	Poor	Droughty, slope								
Wetland	All	Very Poor	No water, slope								

\*Indicator Species

# SOIL SURVEY INTERPRETATIONS

SOIL: Hadley very fine sandy loam, frequently flooded or low bottom phase

STATE: New Hampshire

MAP SYMBOL(S): 8

DATE: 7-73

BRIEF SOIL DESCRIPTION:

MLRA(S): 144

These are well-drained soils that formed in floodwater deposits consisting mainly of very fine sands and silt. Typically these soils have a very dark grayish-brown very fine sandy loam surface layer 10 inches thick. The underlying material to 40 inches is dark grayish-brown and olive silt loam. Below this the texture is variable ranging from very fine sandy loam to sand and gravel. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0-10	vfs1, sil	ML	A-4	100	100	60-85	0.6-2.0	.15-.30	4.5-7.3	Low
10-40	sil, vfs1	ML	A-4	100	100	55-80	0.6-2.0	.13-.26	5.6-7.3	Low
40-72	Variable textures ranging from very fine sandy loam to sand and gravel									
Depth to Bedrock (Ft): <u>5+</u>				Depth to Fragipan (Ft): _____				Depth to Seasonal High Water Table (Ft): <u>4-6+</u>		
Flood Hazard: <u>Severe</u>				Potential Frost Action: <u>High</u>				Hydrologic Group: <u>B</u>		
SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL										
Topsoil	Good									
Sand	Poor: excess fines									
Gravel	Poor: excess fines									
Roadfill	Fair: high potential frost action									
Daily Cover For Landfill	Good									
MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES										
Highway Location	Subject to frequent flooding, high potential frost action									
Pond Reservoir Areas	Subject to frequent flooding, moderate permeability									
Pond Embankments	Moderate slow permeability, subject to piping, erodible									
Sprinkler Irrigation	High available water capacity, moderate intake rate									
Drainage	Frequent flooding, well-drained									
Diversions and Waterways	<u>1/</u>									
DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING										
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use							
Septic Tank Absorption Field	All	Severe	Subject to frequent flooding							
Sewage Lagoon	All	Severe	Subject to frequent flooding							
Dwellings (With Basements)	All	Severe	Subject to frequent flooding							
Dwellings (Without Basements)	All	Severe	Subject to frequent flooding, high potential frost action							
Lawns and Landscaping	All	Severe	Subject to frequent flooding							
Local Roads Streets and Parking Lots	All	Severe	Subject to frequent flooding, high potential frost action							
Shallow Excavations (6 feet or less)	All	Severe	Subject to frequent flooding							

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1/ Practice generally not applied.

EXHIBIT 3-3

Hadley very fine sandy loam, frequently flooded or low bottom phase

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use								
Camp Areas (Tent and Camp Trailers)	All	Severe	Subject to frequent flooding								
Picnic Areas (Park-Type)	All	Moderate	Subject to frequent flooding								
Playgrounds (Athletic Fields)	All	Severe	Subject to frequent flooding								
Paths and Trails (Hiking and Bridle)	All	Moderate	Subject to frequent flooding								
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use	Slope	Suitability	Major Soil Feature(s) Affecting Use								
Truck Crops	All	Fair	Subject to frequent flooding								
Field Crops	All	Fair	Subject to frequent flooding								
Hay and Pasture Crops	All	Good									
Apple Orchards		Not rated									
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to - - -						Productivity			Species to Favor - -	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
All	Slight	Slight	Moderate	Slight	Slight	Slight	3ol	White Pine Red Pine Northern Hardwoods	70-80 70-80 59-66	W.P. S.M. Y.B.	W.P. R.P. W.S.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope	Suitability	Major Soil Feature(s) Affecting Use							
Openland		All	Fair	Subject to frequent flooding							
Woodland		All	Good								
Wetland		All	Very Poor	Deep to water table							

\* Indicator Species

# SOIL SURVEY INTERPRETATIONS

SOIL: Hadley very fine sandy loam, occasionally flooded or high bottom phase

STATE: New Hampshire

MAP SYMBOL(S): BH

DATE: 7-73

BRIEF SOIL DESCRIPTION:

MLRA(S): 144

These are well-drained soils that formed in floodwater deposits consisting mainly of very fine sands and silt. Typically these soils have a very dark grayish-brown very fine sandy loam surface layer about 10 inches thick. The underlying material to 40 inches is dark grayish-brown and olive silt loam. Below this the texture is variable ranging from very fine sandy loam to sand and gravel. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 to 10 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0-10	vfs1, sil	ML	A-4	100	100	60-85	0.6-2.0	.15-.30	4.5-7.3	Low
10-40	sil, vfs1	ML	A-4	100	100	55-80	0.6-2.0	.13-.28	5.6-7.3	Low
40-72	Variable textures ranging from very fine sandy loam to sand and gravel									

Depth to Bedrock (Ft): 5+

Depth to Fragipan (Ft):

Depth to Seasonal High Water Table (Ft): 4-6+

Flood Hazard: Moderate

Potential Frost Action: High

Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL	
Topsoil	Good
Sand	Poor: excess fines
Gravel	Poor: excess fines
Roadfill	Fair: high potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES	
Highway Location	Subject to occasional flooding, high potential frost action
Pond Reservoir Areas	Subject to occasional flooding, moderate permeability
Pond Embankments	Moderately slow permeability, subject to piping, erodible
Sprinkler Irrigation	High available water capacity, moderate intake rate
Drainage	Occasional flooding, well-drained
Diversions and Waterways	1/

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Subject to occasional flooding
Sewage Lagoon	All	Severe	Subject to occasional flooding
Dwellings (With Basements)	All	Severe	Subject to occasional flooding
Dwellings (Without Basements)	All	Severe	Subject to occasional flooding
Lawns and Landscaping	All	Slight	
Local Roads, Streets and Parking Lots	All	Moderate	Subject to occasional flooding
Shallow Excavations (6 feet or less)	All	Severe	Subject to occasional flooding

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1/ Practices generally not applied.

EXHIBIT 3-4



Hedley very fine sandy loam, occasionally flooded or high bottom phase

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use								
Camp Areas (Tent and Camp Trailers)	A11	Moderate	Subject to occasional flooding								
Picnic Areas (Park-Type)	A11	Slight									
Playgrounds (Athletic Fields)	A11	Moderate	Subject to occasional flooding								
Paths and Trails (Hiking and Bridle)	A11	Slight									
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use	Slope	Suitability	Major Soil Feature(s) Affecting Use								
Truck Crops	A11	Good									
Field Crops	A11	Good									
Hay and Pasture Crops	A11	Good									
Apple Orchards	A11	Not rated									
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to - - -						Productivity			Species to Favor - -	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
A11	Slight	Slight	Moderate	Slight	Slight	Slight	301	White Pine Red Pine Northern Hardwoods	70-80 70-80 59-66	W.P. S.M. Y.B.	W.P. R.P. W.S.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope	Suitability	Major Soil Feature(s) Affecting Use							
Openland		A11	Good								
Woodland		A11	Good								
Wetland		A11	Very Poor	Deep to water table							

\* Indicator Species

# SOIL SURVEY INTERPRETATIONS

SOIL: Hartland very fine sandy loam

MAP SYMBOL(S): 30

## BRIEF SOIL DESCRIPTION:

These are well-drained soils that formed in silts and very fine sands. Typically these soils have a dark grayish-brown very fine sandy loam surface layer 6 inches thick. The subsoil between 6 and 19 inches is olive brown and light olive brown very fine sandy loam. Below this to 48 inches is dark grayish-brown, light olive brown and olive silt and very fine sand varves. These soils occupy terraces or lake plains. Slopes range from 0 to 35 percent.

STATE: New Hampshire

DATE: 7-73

MLRA(S): 143, 144

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHO	4	10	200				
0- 6	vfsl, sil	ML	A-4	100	100	70-90	0.6-2.0	.17-.30	5.1-6.0	Low
6-19	vfsl, sil	ML	A-4	100	100	65-85	0.6-2.0	.15-.26	5.1-6.0	Low
19-48	vfsl, sil, lvfs, si, vfs	ML ML-CL	A-4	100	100	55-90	0.2-0.6	.10-.26	5.1-6.0	Low

Depth to Bedrock (Ft): <u>5+</u>	Depth to Fragipan (Ft): _____	Depth to Seasonal High Water Table (Ft): <u>4-5+</u>
Flood Hazard: <u>None</u>	Potential Frost Action: <u>High</u>	Hydrologic Group: <u>B</u>

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL	
Topsoil	Good
Sand	Poor: excess fines
Gravel	Unsuited: excess fines
Roadfill	Poor: high potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES	
Highway Location	High potential frost action, cut slopes erodible
Pond Reservoir Areas	Moderately slow permeability
Pond Embankments	Moderately slow permeability, susceptible to piping, erodible
Sprinkler Irrigation	High available water capacity
Drainage	Well-drained
Diversions and Waterways	Moderately slow permeability, high available water capacity

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Moderately slow permeability
Sewage Lagoon	A & B C, D & E	Moderate Severe	Leakage in floor of lagoon Slope
Dwellings (With Basements)	A, B & C D & E	Moderate Severe	High in fines Slope
Dwellings (Without Basements)	A, B & C D & E	Severe Severe	High potential frost action High potential frost action, slope
Lawns and Landscaping	A & B C D & E	Slight Moderate Severe	Slope Slope
Local Roads, Streets and Parking Lots	A & B C, D & E	Severe Severe	High potential frost action High potential frost action, slope
Shallow Excavations (6 feet or less)	A & B C D & E	Slight Moderate Severe	Slope Slope

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Hartland very fine sandy loam

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use								
Camp Areas (Tent and Camp Trailers)	A, B & C D & E	Moderate Severe	Moderately slow permeability Slope								
Picnic Areas (Park-Type)	A & B C D & E	Slight Moderate Severe	Slope Slope								
Playgrounds (Athletic Fields)	A & B C, D & E	Moderate Severe	Moderately slow permeability Slope								
Paths and Trails (Hiking and Bridle)	A, B & C D E	Slight Moderate Severe	Slope Slope								
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use	Slope	Suitability	Major Soil Feature(s) Affecting Use								
Truck Crops	A B C, D & E	Good Fair Unsuited	Erosion Slope								
Field Crops	A B C D & E	Good Fair Poor Unsuited	Slope Slope Slope								
Hay and Pasture Crops	A & B C D E	Good Fair Poor Unsuited	Slope Slope Slope								
Apple Orchards	All	Not rated									
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to --						Productivity			Species to Favor --	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
A & B	Slight	Slight	Moderate	Slight	Slight	Slight	3ol	White Pine Red Oak	70-80 65-75	W.P. R.O.	W.P. R.P.
C	Slight	Slight	Moderate	Slight	Moderate	Slight	3rl	Northern Hardwood	59-66	S.M.	W.S.
D & E	Slight	Slight	Moderate	Slight	Severe	Moderate	3rl	Red Pine	70-80	Y.B.	
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use								
Openland	A, B & C D & E	Good Fair	Slope Slope								
Woodland	All	Good	Slope								
Wetland	All	Very Poor	Deep to water table								

\*Indicator Species

# SOIL SURVEY INTERPRETATIONS

SOIL: Limerick silt loam

MAP SYMBOL(S): 009

BRIEF SOIL DESCRIPTION:

STATE: New Hampshire

DATE: 7-73

MLRA(S): 143, 144

These are poorly drained soils that formed in recent floodwater deposits consisting mainly of very fine sand and silt. Typically these soils have a very dark grayish-brown silt loam surface layer 5 inches thick. The underlying material to 40 inches is olive gray and dark gray silt loam. Mottles are common below 5 inches. Slopes range from 0 to 3 percent. Flooding from adjacent streams occurs at least once a year.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0- 5	sil, vfs1	ML	P-4	100	100	60-85	0.6-2.0	.15-.30	5.1-6.5	Low
5-40	sil, vfs1	ML	P-4	100	100	55-80	0.6-2.0	.13-.26	5.6-7.3	Low

Depth to Bedrock (Ft): 5+

Depth to Fragipan (Ft): \_\_\_\_\_

Depth to Seasonal

Flood Hazard: Severe

Potential Frost Action: High

High Water Table (Ft): 0-1  
Hydrologic Group: C

## SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Poor: wetness
Sand	Unsuited: excess fines
Gravel	Unsuited: excess fines
Roadfill	Poor: wetness, high potential frost action
Daily Cover For Landfill	Poor: wetness

## MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	High water table, frequent flooding, high potential frost action
Pond Reservoir Areas	High water table, frequent flooding, moderate permeability
Pond Embankments	Moderately slow permeability, subject to piping, high water table
Sprinkler Irrigation	1/
Drainage	High water table, frequent flooding
Diversions and Waterways	1/

## DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	A11	Severe	High water table, frequent flooding
Sewage Lagoon	A11	Severe	Frequent flooding
Dwellings (With Basements)	A11	Severe	High water table, frequent flooding
Dwellings (Without Basements)	A11	Severe	High water table, frequent flooding, high potential frost action
Lawns and Landscaping	A11	Severe	High water table, frequent flooding
Local Roads, Streets and Parking Lots	A11	Severe	High water table, frequent flooding, high potential frost action
Shallow Excavations (6 feet or less)	A11	Severe	High water table, frequent flooding

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1/ Practices generally not applied.

EXHIBIT 3-6

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use		Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use							
Camp Areas (Tent and Camp Trailers)		A11	Severe	High water table, frequent flooding							
Picnic Areas (Park-Type)		A11	Severe	High water table							
Playgrounds (Athletic Fields)		A11	Severe	High water table, frequent flooding							
Paths and Trails (Hiking and Bridle)		A11	Severe	High water table							
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use		Slope	Suitability	Major Soil Feature(s) Affecting Use							
Truck Crops		A11	Unsuited	High water table							
Field Crops		A11	Unsuited	High water table							
Hay and Pasture Crops		A11	Poor	High water table							
Apple Orchards		A11	Unsuited	High water table							
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to - - -						Productivity			Species to Favor - -	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
	Hardwood	Conifer									
A11	Severe	Severe	Severe	Severe	Slight	Severe	4w1	White Pine Red Maple Red Spruce	60-70 70-80 40-50	W.P. R.P. R.M. Hem.	W.P. W.S.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope	Suitability	Major Soil Feature(s) Affecting Use							
Openland		A11	Fair	High water table, flooding							
Woodland		A11	Fair	High water table, flooding							
Wetland		A11	Good								

\* Indicator Species

## SOIL SURVEY INTERPRETATIONS

SOIL: Mixed alluvial land

MAP SYMBOL(S): .7

BRIEF SOIL DESCRIPTION:

Mixed alluvial land occupies nearly level areas of the floodplain. The deposits are generally quite recent and variable in composition. High water table and frequent flooding keeps these areas wet for long periods. Slopes range from 0 to 2 percent.

STATE: New Hampshire

DATE: 7-73

MLRA(S): 143, 144

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
Too Variable to Estimate										
Depth to Bedrock (Ft): <u>5+</u>		Depth to Fragipan (Ft): _____		Depth to Seasonal High Water Table (Ft): <u>0-2½</u>						
Flood Hazard: <u>Severe</u>		Potential Frost Action: <u>High</u>		Hydrologic Group: <u>B-C</u>						
SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL										
Topsoil	Too variable to rate									
Sand	Too variable to rate									
Gravel	Too variable to rate									
Roadfill	Too variable to rate									
Daily Cover For Landfill	Too variable to rate									
MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES										
Highway Location	Frequent flooding, high water table									
Pond Reservoir Areas	Frequent flooding, high water table									
Pond Embankments	Frequent flooding, high water table									
Sprinkler Irrigation	Frequent flooding, high water table									
Drainage	Frequent flooding, high water table									
Diversions and Waterways	Frequent flooding, high water table									
DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING										
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use							
Septic Tank Absorption Field	All	Severe	Frequent flooding, high water table							
Sewage Lagoon	All	Severe	Frequent flooding, high water table							
Dwellings (With Basements)	All	Severe	Frequent flooding, high water table							
Dwellings (Without Basements)	All	Severe	Frequent flooding, high water table							
Lawns and Landscaping	All	Severe	Frequent flooding, high water table							
Local Roads, Streets and Parking Lots	All	Severe	Frequent flooding, high water table							
Shallow Excavations (6 feet or less)	All	Severe	Frequent flooding, high water table							

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EXHIBIT 3-7

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use								
Camp Areas (Tent and Camp Trailers)	All	Severe	Frequent flooding, high water table								
Picnic Areas (Park-Type)	All	Severe	Frequent flooding, high water table								
Playgrounds (Athletic Fields)	All	Severe	Frequent flooding, high water table								
Paths and Trails (Hiking and Bridle)	All	Severe	Frequent flooding, high water table								
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use	Slope	Suitability	Major Soil Feature(s) Affecting Use								
Truck Crops	All	Unsuited	Frequent flooding, high water table								
Field Crops	All	Unsuited	Frequent flooding, high water table								
Hay and Pasture Crops	All	Unsuited	Frequent flooding, high water table								
Apple Orchards	All	Unsuited	Frequent flooding, high water table								
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to ---					Productivity			Species to Favor ---		
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
		Too variable to rate									
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use								
Openland	All	Unsuited	Frequent flooding, high water table								
Woodland	All	Unsuited	Frequent flooding, high water table								
Wetland	All	Good									

# SOIL SURVEY INTERPRETATIONS

SOIL: Ondawa fine sandy loam, frequently flooded or low bottom phase

STATE: New Hampshire

MAP SYMBOL(S): 1

DATE: 7-73

BRIEF SOIL DESCRIPTION:

MLRA(S): 143, 144

These are well-drained soils that formed in sandy floodwater deposits. Typically these soils have a dark brown fine sandy loam surface layer 8 inches thick. The subsoil from 8 to 32 inches is yellowish-brown and light olive brown fine sandy loam. Below this to 48 inches is light yellowish-brown loamy fine sand. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0-8	fel	SM, ML	A-2 A-4	100	95-100	40-55	2.0-6.0	.11-.23	4.5-6.0	Low
8-32	fel, sl	SM, ML	A-2 A-4	100	95-100	25-45	2.0-6.0	.09-.18	4.5-6.0	Low
32-48	lfs, s	SM, SP-SM	A-2 A-3	90-100	80-100	5-30	>6.0	.01-.13	4.5-6.0	Very Low

Depth to Bedrock (Ft): <u>5+</u>	Depth to Fragipan (Ft): _____	Depth to Seasonal High Water Table (Ft): <u>4-6+</u>
Flood Hazard: <u>Severe</u>	Potential Frost Action: <u>Moderate</u>	Hydrologic Group: <u>B</u>

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL	
Topsoil	Good
Sand	Poor: excess fines
Gravel	Unsuited: excess fines
Roadfill	Fair: moderate potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES	
Highway Location	Subject to frequent flooding, moderate potential frost action
Pond Reservoir Areas	Subject to frequent flooding, moderately rapid permeability
Pond Embankments	Moderate permeability, subject to piping
Sprinkler Irrigation	High available water capacity, frequent flooding
Drainage	Frequent flooding, well-drained
Diversions and Waterways	1/

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Subject to frequent flooding
Sewage Lagoon	All	Severe	Subject to frequent flooding
Dwellings (With Basements)	All	Severe	Subject to frequent flooding
Dwellings (Without Basements)	All	Severe	Subject to frequent flooding
Lawns and Landscaping	All	Severe	Subject to frequent flooding
Local Roads, Streets and Parking Lots	All	Severe	Subject to frequent flooding
Shallow Excavations (6 feet or less)	All	Severe	Subject to frequent flooding

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1/ Practice generally not applied.

EXHIBIT 3-8



Ondawa fine sandy loam, frequently flooded or low bottom phase

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use		Slope		Degree of Limitation		Major Soil Feature(s) Affecting Use					
Camp Areas (Tent and Camp Trailers)		A11		Severe		Subject to frequent flooding					
Picnic Areas (Park-Type)		A11		Moderate		Subject to frequent flooding					
Playgrounds (Athletic Fields)		A11		Severe		Subject to frequent flooding					
Paths and Trails (Hiking and Bridle)		A11		Moderate		Subject to frequent flooding					
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Truck Crops		A11		Fair		Subject to frequent flooding					
Field Crops		A11		Fair		Subject to frequent flooding					
Hay and Pasture Crops		A11		Good							
Apple Orchards		A11		Not rated							
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to - - -						Productivity			Species to Favor - -	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
Hardwood		Conifer									
A11	Slight	Slight	Moderate	Slight	Slight	Slight	4c1	White Pine Red Pine Red Spruce Northern Hardwoods	60-70 60-70 40-50 52-59	W.P. R.P. R.O. S.M. Y.B.	W.P. R.P. W.S.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Openland		A11		Fair		Subject to frequent flooding					
Woodland		A11		Good							
Wetland		A11		Very Poor		Deep to water table					

\* Indicator Species

# SOIL SURVEY INTERPRETATIONS

SOIL: Ondawa fine sandy loam, occasionally flooded or high bottom phase

STATE: New Hampshire

MAP SYMBOL(S): 1H

DATE: 7-73

BRIEF SOIL DESCRIPTION:

MLRA(S): 143, 144

These are well-drained soils that formed in sandy floodwater deposits. Typically these soils have a dark brown fine sandy loam surface layer 8 inches thick. The subsoil from 8 to 32 inches is yellowish-brown and light olive brown fine sandy loam. Below this to 48 inches is light yellowish-brown loamy fine sand. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 to 10 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. ____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0-8	fsl	SM, ML	A-2 A-4	100	95-100	40-65	2.0-6.0	.11-.23	4.5-6.0	Low
8-32	fsl, sl	SM, ML	A-2 A-4	100	95-100	25-45	2.0-6.0	.09-.18	4.5-6.0	Low
32-48	lfs, s	SM, SP-SM	A-2 A-3	90-100	80-100	5-30	>6.0	.01-.13	4.5-6.0	Very Low

Depth to Bedrock (Ft): <u>5+</u>	Depth to Fragipan (Ft): _____	Depth to Seasonal High Water Table (Ft): <u>4-6+</u>
Flood Hazard: <u>Moderate</u>	Potential Frost Action: <u>Moderate</u>	Hydrologic Group: <u>B</u>

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL	
Topsoil	Good
Sand	Poor: excess fines
Gravel	Unsuited: excess fines
Roadfill	Fair: moderate potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES	
Highway Location	Subject to occasional flooding
Pond Reservoir Areas	Subject to occasional flooding, moderately rapid permeability
Pond Embankments	Moderate permeability, subject to piping
Sprinkler Irrigation	High available water capacity, occasional flooding
Drainage	Occasional flooding, well-drained
Diversions and Waterways	<u>1/</u>

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Subject to occasional flooding
Sewage Lagoon	All	Severe	Subject to occasional flooding
Dwellings (With Basements)	All	Severe	Subject to occasional flooding
Dwellings (Without Basements)	All	Severe	Subject to occasional flooding
Lawns and Landscaping	All	Slight	
Local Roads, Streets and Parking Lots	All	Moderate	Subject to occasional flooding
Shallow Excavations (6 feet or less)	All	Severe	Subject to occasional flooding

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1/ Practice generally not applied.

EXHIBIT 3-9

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use								
Camp Areas (Tent and Camp Trailers)	A11	Moderate	Subject to occasional flooding								
Picnic Areas (Park-Type)	A11	Slight									
Playgrounds (Athletic Fields)	A11	Moderate	Subject to occasional flooding								
Paths and Trails (Hiking and Bridle)	A11	Slight									
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use	Slope	Suitability	Major Soil Feature(s) Affecting Use								
Truck Crops	A11	Good									
Field Crops	A11	Good									
Hay and Pasture Crops	A12	Good									
Apple Orchards	A11	Not rated									
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to - - -						Productivity			Species to Favor - -	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
A11	Slight	Slight	Moderate	Slight	Slight	Slight	401	White Pine Red Pine Red Spruce Northern Hardwoods	60-70 60-70 40-50 52-59	W.P. R.P. R.O. S.M. Y.B.	W.P. R.P. W.S.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife	Slope	Suitability	Major Soil Feature(s) Affecting Use								
Openland	A11	Good									
Woodland	A11	Good									
Wetland	A11	Very Poor	Deep to water table								

\* Indicator Species

# SOIL SURVEY INTERPRETATIONS

SOIL: Onawa sandy loam

MAP SYMBOL(S): 25

BRIEF SOIL DESCRIPTION:

These are well-drained soils that formed in sandy floodwater deposits. Typically these soils have a dark brown sandy loam surface layer 8 inches thick. The subsoil from 8 to 32 inches is yellowish-brown and light olive brown sandy loam. Below this to 48 inches is light yellowish-brown loamy sand. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

STATE: New Hampshire

DATE: 7-73

MLRA(S): 143, 144

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0-8	sl	SM, ML	A-2 A-4	100	95-100	30-55	2.0-6.0	.11-.18	4.5-6.0	Low
8-32	sl, fsl	SM	A-2	100	95-100	25-45	2.0-6.0	.09-.18	4.5-6.0	Low
32-48	ls, s	SM, SP-SM	A-2 A-3	90-100	80-95	5-30	> 6.0	.01-.13	4.5-6.0	Very Low

Depth to Bedrock (Ft): <u>5+</u>	Depth to Fragipan (Ft): _____	Depth to Seasonal High Water Table (Ft): <u>4-6+</u>
Flood Hazard: <u>Severe</u>	Potential Frost Action: <u>Moderate</u>	Hydrologic Group: <u>B</u>

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL	
Topsoil	Good
Sand	Poor: excess fines
Gravel	Unsuited: excess fines
Roadfill	Fair: moderate potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES	
Highway Location	Subject to frequent flooding, moderate potential frost action
Pond Reservoir Areas	Subject to frequent flooding, moderately rapid permeability
Pond Embankments	Moderate permeability, subject to piping
Sprinkler Irrigation	Moderate available water capacity, frequent flooding
Drainage	Subject to frequent flooding, well-drained
Diversions and Waterways	1/

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Subject to frequent flooding
Sewage Lagoon	All	Severe	Subject to frequent flooding
Dwellings (With Basements)	All	Severe	Subject to frequent flooding
Dwellings (Without Basements)	All	Severe	Subject to frequent flooding
Lawns and Landscaping	All	Severe	Subject to frequent flooding
Local Roads, Streets and Parking Lots	All	Severe	Subject to frequent flooding
Shallow Excavations (6 feet or less)	All	Severe	Subject to frequent flooding

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 1/ Practice generally not applied.

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EXHIBIT 3-10

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use		Slope		Degree of Limitation		Major Soil Feature(s) Affecting Use					
Camp Areas (Tent and Camp Trailers)		A11		Severe		Subject to frequent flooding					
Picnic Areas (Park-Type)		A11		Moderate		Subject to frequent flooding					
Playgrounds (Athletic Fields)		A11		Severe		Subject to frequent flooding					
Paths and Trails (Hiking and Bridle)		A11		Moderate		Subject to frequent flooding					
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Truck Crops		A11		Fair		Subject to frequent flooding					
Field Crops		A11		Fair		Subject to frequent flooding					
Hay and Pasture Crops		A11		Good							
Apple Orchards		A11		Not rated							
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to - - -						Productivity			Species to Favor - -	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restric- tions	Suit- ability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
A11	Slight	Slight	Moderate	Slight	Slight	Slight	4o1	White Pine Red Pine Red Spruce Northern Hardwoods	60-70 60-70 40-50 52-59	W.P. R.P. R.O.	W.P. R.P. W.S.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Openland		A11		Fair		Subject to frequent flooding					
Woodland		A11		Good							
Wetland		A11		Very Poor		Deep to water table					

\* Indicator Species

# SOIL SURVEY INTERPRETATIONS

SOIL: Podunk fine sandy loam

MAP SYMBOL(S): 4

BRIEF SOIL DESCRIPTION:

These are moderately well drained soils that formed in sandy floodwater deposits. Typically these soils have a dark yellowish-brown fine sandy loam surface layer 8 inches thick. The subsoil from 8 to 30 inches is light olive brown fine sandy loam. Below this to 48 inches is olive gray loamy fine sand. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

STATE: New Hampshire

DATE: 7-73

MLRA(S): 143, 144

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0-8	fsl, sl	SM, ML	A-4	95-100	90-100	35-55	0.6-2.0	.11-.23	4.5-6.0	Low
8-30	fsl, sl	SM	A-2 A-4	95-100	85-95	30-50	2.0-6.0	.08-.17	4.5-6.0	Low
30-48	lfs, ls, s	SM, SP-SM	A-2 A-3	90-100	80-100	5-30	2.0-6.0	.01-.13	4.5-6.0	Low

Depth to Bedrock (Ft): 5+

Depth to Fragipan (Ft): \_\_\_\_\_

Depth to Seasonal

Flood Hazard: Severe

Potential Frost Action: High

High Water Table (Ft): 1-2 1/2

Hydrologic Group: B

## SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL

Topsoil	Good
Sand	Poor 1/2: excess fines
Gravel	Unsuited: excess fines
Roadfill	Poor: high potential frost action
Daily Cover For Landfill	Good

## MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES

Highway Location	Seasonal high water table, frequent flooding, high potential frost action
Pond Reservoir Areas	Moderately rapid permeability, seasonal high water table, frequent flooding
Pond Embankments	Moderate permeability, subject to piping
Sprinkler Irrigation	Seasonal high water table, moderate available water capacity
Drainage	Seasonal high water table, moderately rapid permeability, frequent flooding
Diversions and Waterways	Frequent flooding, nearly level slopes

## DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING

Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Seasonal high water table, frequent flooding
Sewage Lagoon	All	Severe	Frequent flooding, moderately rapid permeability
Dwellings (With Basements)	All	Severe	Seasonal high water table, frequent flooding
Dwellings (Without Basements)	All	Severe	Subject to frequent flooding, high potential frost action
Lawns and Landscaping	All	Severe	Frequent flooding
Local Roads, Streets and Parking Lots	All	Severe	Frequent flooding, high potential frost action
Shallow Excavations (6 feet or less)	All	Severe	Frequent flooding

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1/ Rating is fair below 2 1/2 feet.

EXHIBIT 3-11

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use		Slope		Degree of Limitation		Major Soil Feature(s) Affecting Use					
Camp Areas (Tent and Camp Trailers)		All		Severe		Subject to frequent flooding					
Picnic Areas (Park-Type)		All		Moderate		Subject to frequent flooding					
Playgrounds (Athletic Fields)		All		Severe		Subject to frequent flooding					
Paths and Trails (Hiking and Bridle)		All		Slight							
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Truck Crops		All		Poor		Subject to frequent flooding					
Field Crops		All		Fair		Subject to frequent flooding					
Hay and Pasture Crops		All		Good							
Apple Orchards		All		Unsuited		Subject to frequent flooding					
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to ---						Productivity			Species to Favor --	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
All	Slight	Slight	Moderate	Slight	Slight	Slight	3o1	White Pine* Red Oak Northern Hardwoods Red Pine	70-80 65-75 59-66 70-80	W.P. R.P. R.O. S.M. W.A. Y.B.	W.P. R.P. W.S.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Openland		All		Fair		Subject to frequent flooding					
Woodland		All		Good							
Wetland		All		Poor		Fluctuating water table					

\* Indicator Species

# SOIL SURVEY INTERPRETATIONS

SOIL: Podunk fine sandy loam, over sand or gravel

STATE: New Hampshire

MAP SYMBOL(S): 4C

DATE: 7-73

## BRIEF SOIL DESCRIPTION:

MLRA(S): 143, 144

These are moderately well drained soils that formed in sandy floodwater deposits. Typically these soils have a dark yellowish-brown fine sandy loam surface layer 8 inches thick. The subsoil from 8 to 28 inches is light olive brown fine sandy loam. Below this to 48 inches is olive gray sand or gravel. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0-8	fsl, sl	SM, ML	A-4	95-100	90-100	35-55	2.0-6.0	.11-.23	4.5-6.0	Low
8-28	fsl, sl	SM	A-2 A-4	95-100	85-95	30-50	2.0-6.0	.08-.17	4.5-6.0	Low
28-49	sand or gravel	SP, GP	A-1 A-2	40-70	35-65	0-5	>6.0	.01-.05	4.5-5.5	Very Low

Depth to Bedrock (Ft): <u>5+</u>	Depth to Fragipan (Ft): _____	Depth to Seasonal High Water Table (Ft): <u>1-2 1/2</u>
Flood Hazard: <u>Severe</u>	Potential Frost Action: <u>High</u>	Hydrologic Group: <u>8</u>

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL	
Topsoil	Good
Sand	Poor 1/: excess fines
Gravel	Poor 1/: excess fines
Roadfill	Poor: high potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES	
Highway Location	Seasonal high water table, frequent flooding, high potential frost action
Pond Reservoir Areas	Rapid permeability in substratum, seasonal high water table, frequent flooding
Pond Embankments	Moderate permeability, subject to piping
Sprinkler Irrigation	Moderate available water capacity, seasonal high water table
Drainage	Seasonal high water table, moderately rapid permeability, frequent flooding
Diversions and Waterways	Frequent flooding, sand or gravel layers below about 2 1/2, nearly level slopes

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Seasonal high water table, frequent flooding
Sewage Lagoon	All	Severe	Frequent flooding, moderately rapid permeability
Dwellings (With Basements)	All	Severe	Seasonal high water table, frequent flooding
Dwellings (Without Basements)	All	Severe	Subject to frequent flooding, high potential frost action
Lawns and Landscaping	All	Severe	Frequent flooding
Local Roads, Streets and Parking Lots	All	Severe	Frequent flooding, high potential frost action
Shallow Excavations (6 feet or less)	All	Severe	Frequent flooding

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1/ Rating is good below about 2 1/2 feet.

EXHIBIT 3-12



DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use		Slope		Degree of Limitation		Major Soil Feature(s) Affecting Use					
Camp Areas (Tent and Camp Trailers)		All		Severe		Subject to frequent flooding					
Picnic Areas (Park-Type)		All		Moderate		Subject to frequent flooding					
Playgrounds (Athletic Fields)		All		Severe		Subject to frequent flooding					
Paths and Trails (Hiking and Bridle)		All		Slight							
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Truck Crops		All		Poor		Subject to frequent flooding					
Field Crops		All		Fair		Subject to frequent flooding					
Hay and Pasture Crops		All		Good							
Apple Orchards		All		Unsuited		Subject to frequent flooding					
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to -- --						Productivity			Species to Favor -- --	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restric- tions	Suit- ability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
All	Slight	Slight	Moderate	Slight	Slight	Slight	3o1	White Pine* Red Oak Northern Hardwoods Red Pine	70-80 65-75 59-66 70-80	W.P. R.P. R.O. S.M. Y.B. W.A.	W.P. R.P. W.S.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Openland		All		Fair		Subject to frequent flooding					
Woodland		All		Good							
Wetland		All		Poor		Fluctuating water table					

\* Indicator Species

# SOIL SURVEY INTERPRETATIONS

SOIL: Suncook loamy sand

MAP SYMBOL(S): 2

BRIEF SOIL DESCRIPTION:

STATE: New Hampshire

DATE: 7-73

MLRA(S): 143, 144

These are excessively drained soils that formed in sandy alluvial deposits. Typically these soils have a very dark grayish-brown loamy sand surface layer 7 inches thick. The underlying material from 7 to 48 inches is yellowish-brown, grayish-brown and brown loamy sand and loamy fine sand in the upper part grading to medium sand and coarse sand in the lower part. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0- 7	1s, 1fs	SM	A-2	95-100	85-100	15-35	>6.0	.07-.15	4.5-6.5	Low
7-48	1s, 1fs, s, cos	SM, SP	A-1 A-2 A-3	90-100	85-100	0-25	>6.0	.01-.13	4.5-6.5	Very Low
Depth to Bedrock (Ft): <u>6-8+</u> Depth to Fragipan (Ft): _____      Depth to Seasonal High Water Table (Ft): <u>3-6+</u> Flood Hazard: <u>Severe</u> Potential Frost Action: <u>Low</u> Hydrologic Group: <u>A</u>										
SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL										
Topsoil	Poor: sandy									
Sand	Good									
Gravel	Poor: excess fines									
Roadfill	Good									
Daily Cover For Landfill	Fair: sandy									
MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES										
Highway Location	Subject to flooding, cut slopes unstable									
Pond Reservoir Areas	Subject to flooding, rapid permeability									
Pond Embankments	Rapid permeability, fair to poor stability									
Sprinkler Irrigation	Low available water capacity									
Drainage	1/									
Diversions and Waterways	1/									
DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING										
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use							
Septic Tank Absorption Field	A	Severe	Subject to flooding							
Sewage Lagoon	A	Severe	Rapid permeability, subject to flooding							
Dwellings (With Basements)	A	Severe	Subject to flooding							
Dwellings (Without Basements)	A	Severe	Subject to flooding							
Lawns and Landscaping	A	Severe	Subject to flooding							
Local Roads, Streets and Parking Lots	A	Severe	Subject to flooding							
Shallow Excavations (6 feet or less)	A	Severe	Subject to flooding							

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1/ Practice generally not applied.

EXHIBIT 3-13

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use		Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use							
Camp Areas (Tent and Camp Trailers)		A	Severe	Subject to flooding							
Picnic Areas (Park-Type)		A	Moderate	Subject to flooding							
Playgrounds (Athletic Fields)		A	Severe	Subject to flooding							
Paths and Trails (Hiking and Bridle)		A	Slight								
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use		Slope	Suitability	Major Soil Feature(s) Affecting Use							
Truck Crops		A	Unsuited	Subject to flooding							
Field Crops		A	Poor	Droughty							
Hay and Pasture Crops		A	Poor	Droughty							
Apple Orchards		A	Unsuited	Subject to flooding							
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to ---						Productivity			Species to Favor ---	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
Hardwood		Conifer									
All	Severe	Slight	Slight	Slight	Slight	Slight	5sl	White Pine Red Pine	* 50-60 50-60	W.P. R.P.	W.P. R.P.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope	Suitability	Major Soil Feature(s) Affecting Use							
Openland		A	Poor	Sandy, subject to flooding							
Woodland		A	Poor	Sandy, subject to flooding							
Wetland		A	Very Poor	Sandy, deep to water							

\* Indicator Species

# SOIL SURVEY INTERPRETATIONS

SOIL: Windsor loamy sand

MAP SYMBOL(S): 26

BRIEF SOIL DESCRIPTION:

These are excessively drained soils that formed in thick deposits of sand. Typically these soils have a dark brown loamy sand surface layer about 8 inches thick. The subsoil to 25 inches is yellowish-brown and brownish-yellow loamy sand. Below this to 55 inches is light yellowish-brown and pale yellow sand. These soils occupy terraces, outwash plains and deltas. Slopes range from 0 to 60 percent.

STATE: New Hampshire

DATE: 7-73

MLRA(S): 143, 144

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0-8	ls, lfs	SM	A-2	95-100	90-100	20-35	>6.0	.08-.15	4.5-5.5	Very Low
8-25	ls, lfs	SM	A-2	95-100	90-100	15-30	>6.0	.06-.13	4.5-5.5	Very Low
25-55	s, fs	SP, SM	A-2 A-3	90-100	85-100	0-20	>6.0	.01-.08	4.5-5.5	Very Low

Depth to Bedrock (Ft): 6-8+

Depth to Fragipan (Ft): ----

Depth to Seasonal High Water Table (Ft): 6+

Flood Hazard: None

Potential Frost Action: Low

Hydrologic Group: A

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL	
Topsoil	Poor: sandy
Sand	Good
Gravel	Poor: excess fines
Roadfill	Good
Daily Cover For Landfill	Fair: sandy

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES	
Highway Location	Cut slopes unstable, erodible
Pond Reservoir Areas	Rapid permeability
Pond Embankments	Rapid permeability, erodible
Sprinkler Irrigation	Very low available water capacity
Drainage	<u>1/</u>
Diversions and Waterways	Rapid permeability, very low available water capacity

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	A & B C D & E	Slight Moderate <u>2/</u> Severe	Slope Slope
Sewage Lagoon	A & B C, D & E	Severe <u>2/</u> Severe <u>2/</u>	Rapid permeability Rapid permeability, slope
Dwellings (With Basements)	A & B C D & E	Slight Moderate Severe	Slope Slope
Dwellings (Without Basements)	A & B C D & E	Slight Moderate Severe	Slope Slope
Lawns and Landscaping	A, B & C D & E	Severe Severe	Droughty Droughty, slope
Local Roads, Streets and Parking Lots	A B C, D & E	Slight Moderate Severe	Slope Slope
Shallow Excavations (6 feet or less)	A, B & C D & E	Severe Severe	Sloughing Sloughing, slope

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1/ Practice generally not applied.

2/ Potential pollution hazard to nearby wells, streams, and lakes.

EXHIBIT 3-14

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use		Slope		Degree of Limitation		Major Soil Feature(s) Affecting Use					
Camp Areas (Tent and Camp Trailers)		A, B & C D & E		Moderate Severe		Sandy Slope					
Picnic Areas (Park-Type)		A, B & C D & E		Moderate Severe		Sandy Slope					
Playgrounds (Athletic Fields)		A & B C, D & E		Moderate Severe		Sandy Slope					
Paths and Trails (Hiking and Bridle)		A, B, C & D E		Moderate Severe		Sandy Slope					
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Truck Crops		A & B C, D & E		Poor Unsuited		Droughty Slope					
Field Crops		A & B C, D & E		Poor Unsuited		Droughty Slope					
Hay and Pasture Crops		A & B C D & E		Fair Poor Unsuited		Droughty Slope Slope					
Apple Orchards		All		Unsuited		Droughty, slope					
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to -- --						Productivity			Species to Favor --	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restric- tions	Suit- ability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
A, B & C	Severe	Slight	Slight	Slight	Slight	Slight	5s1	White Pine	50-60	W.P.	W.P.
								Red Pine	50-60	R.P.	R.P.
D & E	Severe	Slight	Slight	Slight	Slight <sup>3/</sup>	Moderated <sup>4/</sup>	5s1	Red Oak	45-55	R.O.	
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Openland		All		Poor		Droughty					
Woodland		All		Poor		Droughty					
Wetland		All		Very Poor		No water					

\* Indicator Species

<sup>3/</sup> Rating is moderate when slopes are greater than 35 percent.<sup>4/</sup> Rating is severe when slopes are greater than 35 percent.

# SOIL SURVEY INTERPRETATIONS

SOIL: Windsor loamy sand, dark mineral substratum phase

MAP SYMBOL(S): 326

BRIEF SOIL DESCRIPTION:

These are excessively drained soils that formed in thick deposits of sand. Typically these soils have a dark brown loamy sand surface layer 8 inches thick. The subsoil to 16 inches is yellowish-brown and light olive brown loamy sand. Below this to 50 inches is very dark gray and gray sand. These soils occupy terraces, outwash plains and deltas. Slopes range from 0 to 60 percent.

STATE: New Hampshire

DATE: 7-73

MLRA(S): 143, 144

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. ____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0-8	ls, lfs	SM	A-2	95-100	90-100	20-35	>6.0	.08-.15	4.5-6.5	Very Low
8-16	ls, lfs	SM	A-2	95-100	90-100	15-30	>6.0	.06-.13	4.5-6.5	Very Low
16-50	s, fs	SP, SM	A-2 A-3	90-100	85-100	0-20	>6.0	.01-.08	4.5-6.5	Very Low

Depth to Bedrock (Ft): 6-8+	Depth to Fragipan (Ft): ----	Depth to Seasonal High Water Table (Ft): 6+
Flood Hazard: None	Potential Frost Action: Low	Hydrologic Group: A

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL	
Topsoil	Poor: sandy
Sand	Good
Gravel	Poor: excess fines
Roadfill	Good
Daily Cover For Landfill	Fair: sandy

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES	
Highway Location	Cut slopes unstable, erodible
Pond Reservoir Areas	Rapid permeability
Pond Embankments	Rapid permeability, erodible
Sprinkler Irrigation	Very low available water capacity
Drainage	1/
Diversions and Waterways	Rapid permeability, very low available water capacity

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	A & B C D & E	Slight 2/ Moderate 2/ Severe	Slope Slope
Sewage Lagoon	A & B C, D & E	Severe 2/ Severe 2/	Rapid permeability Rapid permeability, slope
Dwellings (With Basements)	A & B C D & E	Slight Moderate Severe	Slope Slope
Dwellings (Without Basements)	A & B C D & E	Slight Moderate Severe	Slope Slope
Lawns and Landscaping	A, B & C D & E	Severe Severe	Droughty Droughty, slope
Local Roads, Streets and Parking Lots	A B C, D & E	Slight Moderate Severe	Slope Slope
Shallow Excavations (6 feet or less)	A, B & C D & E	Severe Severe	Sloughing Sloughing, slope

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1/ Practice generally not applied.

2/ Potential pollution hazard to nearby wells, streams and lakes.

EXHIBIT 3-15

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use		Slope		Degree of Limitation		Major Soil Feature(s) Affecting Use					
Camp Areas (Tent and Camp Trailers)		A, B & C D & E		Moderate Severe		Sandy Slope					
Picnic Areas (Park-Type)		A, B & C D & E		Moderate Severe		Sandy Slope					
Playgrounds (Athletic Fields)		A & B C, D & E		Moderate Severe		Sandy Slope					
Paths and Trails (Hiking and Bridle)		A, B, C & D E		Moderate Severe		Sandy Slope					
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Truck Crops		A & B C, D & E		Poor Unsuited		Droughty Slope					
Field Crops		A & B C, D & E		Poor Unsuited		Droughty Slope					
Hay and Pasture Crops		A & B C D & E		Fair Poor Unsuited		Droughty Slope Slope					
Apple Orchards		All		Unsuited		Droughty, slope					
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to ---						Productivity			Species to Favor ---	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restric- tions	Suit- ability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
A, B & C	Severe	Slight	Slight	Slight	Slight	Slight	5s1	White Pine*	50-60	W.P.	W.P.
D & E	Severe	Slight	Slight	Slight	Slight <sup>3/</sup>	Moderate <sup>4/</sup>	5s1	Red Pine Red Oak	50-60 45-55	R.P. R.O.	R.P.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Openland		All		Poor		Droughty					
Woodland		All		Poor		Droughty					
Wetland		All		Very Poor		No water					

\* Indicator Species

<sup>3/</sup> Rating is moderate when slopes are greater than 35 percent.<sup>4/</sup> Rating is severe when slopes are greater than 35 percent.

# SOIL SURVEY INTERPRETATIONS

SOIL: Winooski very fine sandy loam

MAP SYMBOL(S): 9

BRIEF SOIL DESCRIPTION:

These are moderately well drained soils that formed in recent very fine sand and silt floodwater deposits. Typically these soils have a very dark grayish-brown very fine sandy loam surface layer 9 inches thick. Below this to 42 inches is dark grayish-brown and grayish-brown silt loam and very fine sandy loam. Slopes range from 0 to 3 percent. These soils are subject to flooding from adjacent streams at least once in 5 years.

STATE: New Hampshire

DATE: 7-73

MLRA(S): 143, 144

ESTIMATED PHYSICAL AND CHEMICAL PROPERTIES FOR ENGINEERING										
Depth From Surface (Inches)	Classification			Percentage Less Than 3 Inches Passing Sieve No. _____			Permeability (in/hr)	Available Water Capacity (in/in)	Soil Reaction (pH)	Shrink-Swell Potential
	USDA Texture	Unified	AASHTO	4	10	200				
0- 9	vfsl, sil	ML	A-4	100	95-100	65-90	0.6-2.0	.16-.29	5.1-6.5	Low
9-42	vfsl, sil	ML	A-4	100	90-100	60-85	0.6-2.0	.13-.26	5.1-7.3	Low

Depth to Bedrock (Ft): 5+

Depth to Fragipan (Ft): \_\_\_\_\_

Depth to Seasonal High Water Table (Ft): 1-3

Flood Hazard: Severe

Potential Frost Action: High

Hydrologic Group: B

SUITABILITY AND MAJOR FEATURES AFFECTING SOIL AS A RESOURCE MATERIAL	
Topsoil	Good
Sand	Unsuited: excess fines
Gravel	Unsuited: excess fines
Roadfill	Poor: high potential frost action
Daily Cover For Landfill	Good

MAJOR SOIL FEATURES AFFECTING SPECIFIED ENGINEERING USES	
Highway Location	Seasonal high water table, frequent flooding, high potential frost action
Pond Reservoir Areas	Moderate permeability, seasonal high water table, frequent flooding
Pond Embankments	Moderately slow permeability, subject to piping
Sprinkler Irrigation	Seasonal high water table, high available water capacity
Drainage	Seasonal high water table, moderate permeability, frequent flooding
Diversions and Waterways	Frequent flooding, nearly level slopes

DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING TOWN AND COUNTRY PLANNING			
Use	Slope	Degree of Limitation	Major Soil Feature(s) Affecting Use
Septic Tank Absorption Field	All	Severe	Seasonal high water table, frequent flooding
Sewage Lagoon	All	Severe	Frequent flooding
Dwellings (With Basements)	All	Severe	Seasonal high water table, frequent flooding
Dwellings (Without Basements)	All	Severe	Frequent flooding, high potential frost action
Lawns and Landscaping	All	Severe	Frequent flooding
Local Roads, Streets and Parking Lots	All	Severe	Frequent flooding, high potential frost action
Shallow Excavations (6 feet or less)	All	Severe	Frequent flooding

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New Hampshire Agricultural Experiment Station

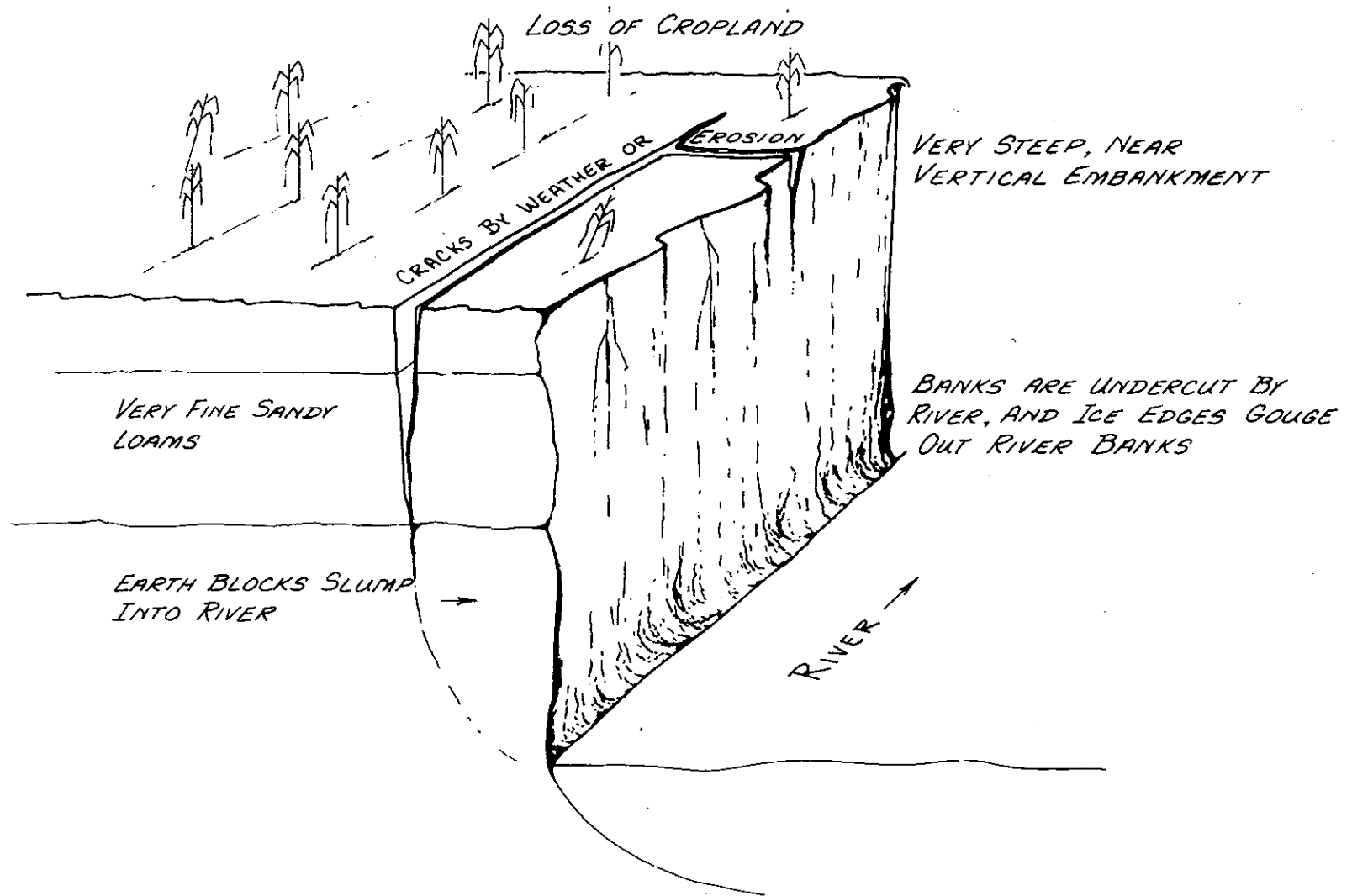
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EXHIBIT 3-16

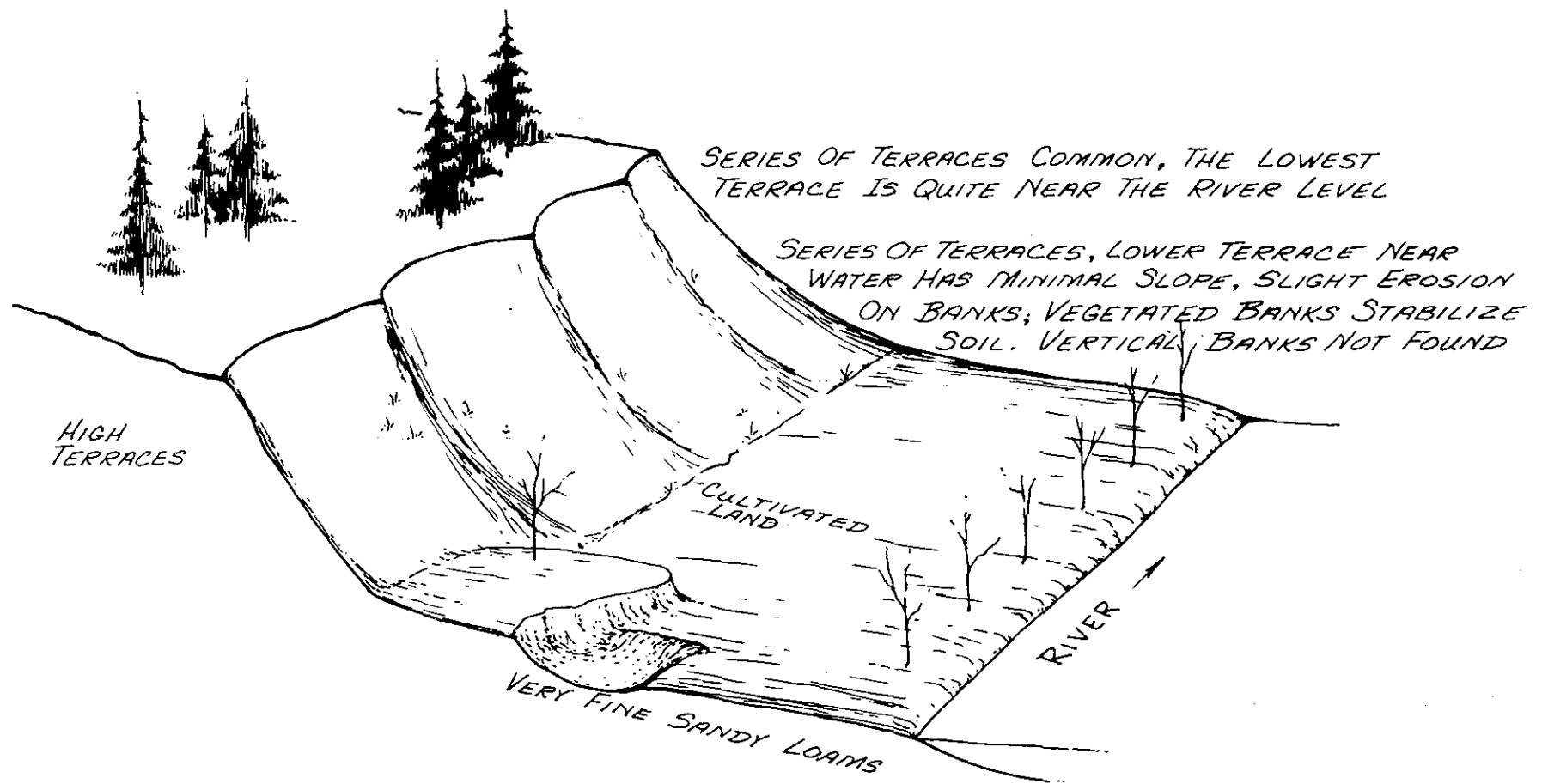


DEGREE OF SOIL LIMITATION AND MAJOR SOIL FEATURES AFFECTING RECREATION DEVELOPMENT											
Use		Slope		Degree of Limitation		Major Soil Feature(s) Affecting Use					
Camp Areas (Tent and Camp Trailers)		All		Moderate		Flooding					
Picnic Areas (Park-Type)		All		Moderate		Flooding					
Playgrounds (Athletic Fields)		All		Moderate		Flooding					
Paths and Trails (Hiking and Bridle)		All		Slight							
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING FARM USE											
Use		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Truck Crops		All		Poor		Frequent flooding					
Field Crops		All		Fair		Frequent flooding					
Hay and Pasture Crops		All		Good							
Apple Orchards		All		Unsuited		Frequent flooding					
SUITABILITY FOR WOODLAND PRODUCTION AND LIMITATIONS FOR MANAGEMENT											
Slope	Degree of Limitation Related to - - -						Productivity			Species to Favor - -	
	Seedling Mortality	Plant Competition		Windthrow Hazard	Erosion Hazard	Equipment Restrictions	Suitability Group	Major Species	Site Index Range	Existing Stands	For Planting
		Hardwood	Conifer								
All	Slight	Slight	Moderate	Slight	Slight	Slight	3 or 1	White Pine* Red Oak Northern Hardwoods	70-80 65-75 60-70	W.P. S.M. Y.B. R.O.	W.P. R.P.
SUITABILITY AND MAJOR SOIL FEATURES AFFECTING USE FOR WILDLIFE											
Kinds of Wildlife		Slope		Suitability		Major Soil Feature(s) Affecting Use					
Openland		All		Fair		Frequent flooding					
Woodland		All		Good							
Wetland		All		Poor		Seasonal high water table					

\* Indicator Species

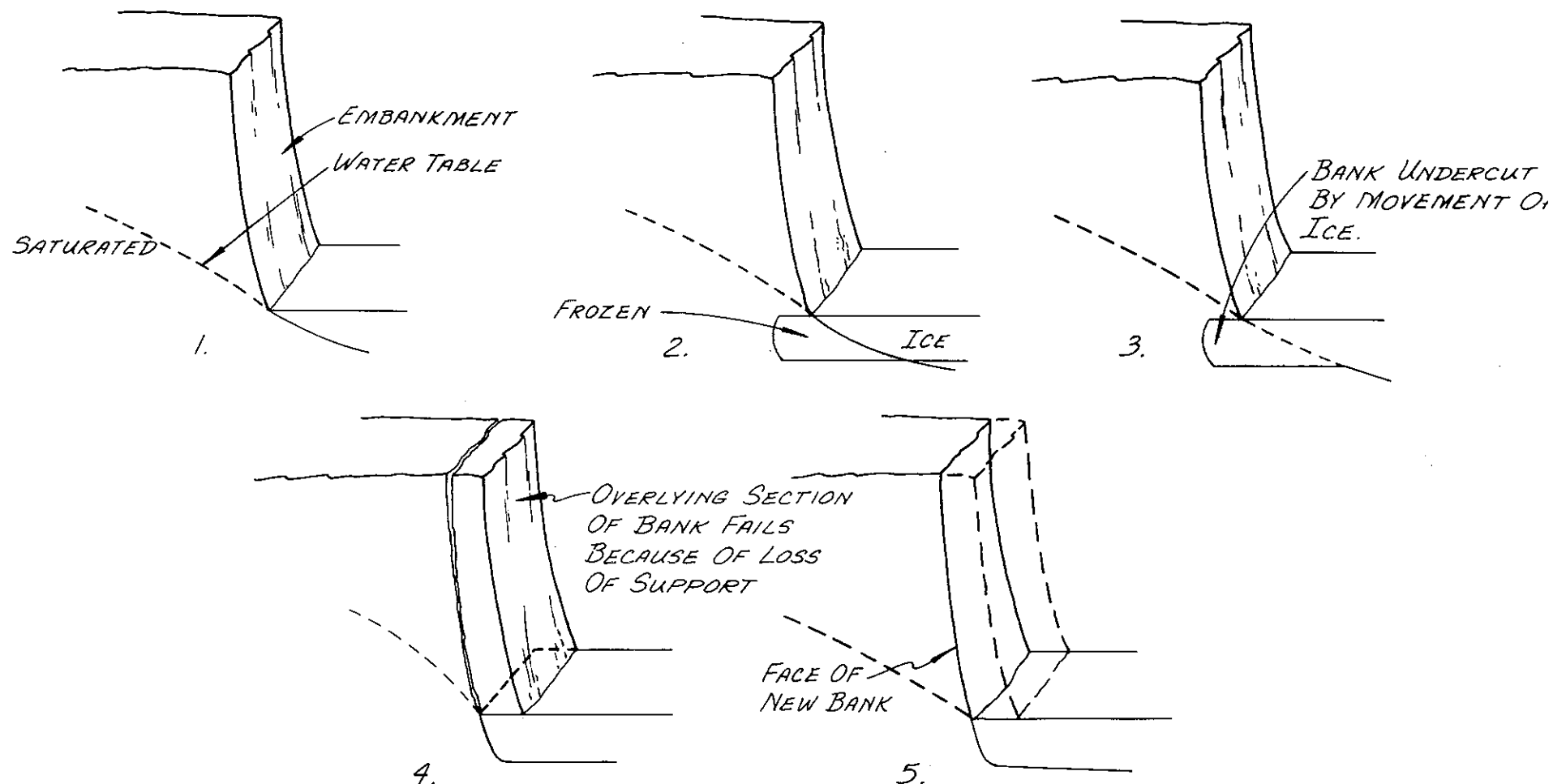


TYPICAL SOIL EROSION AND MASS WASTING  
CHARLESTOWN, SULLIVAN COUNTY, N.H.  
EXHIBIT 4-1



TYPICAL LANDSCAPE, NORTH OF ASCUTNEY BRIDGE  
SULLIVAN COUNTY

EXHIBIT 5-1



# REMOVAL OF SOIL MATERIAL BY ANCHOR ICE

EXHIBIT 6-1

REPORT BY  
NEW ENGLAND POWER COMPANY  
TO  
TECHNICAL COMMITTEE ON BANK EROSION  
ON THE CONNECTICUT RIVER

I. GENERAL

Erosion of the banks of natural rivers is an ever-continuing process, accompanied by deposition in some locations as material is being eroded in others. Where currents are swift, banks are cut away; and where flow is sluggish, accretion occurs, resulting in a meandering river course, featured by ox-bows continually changing in location. As a result, over a long period of time, a wide flood plain is carved out, many times the width of the actual stream.

Similar action occurs when river flow is ponded by a dam or other obstruction; and although this action is retarded by less severe seasonal fluctuation and lower velocities than in a natural river, it continues to exist because the current acts on a higher and sometimes steeper section of river bank.

There are several causes of bank erosion. Some of the more common ones are as follows:

1. Ice Action -- Pond ice can form to a depth of several feet and with pond fluctuation can transmit stress to a river bank and scour material as it pulls loose. The most damage takes place during ice runs when natural grinding action occurs and can be quite severe where jamming occurs.
2. Wave Action -- The undulation of wave action can cause erosion; and where power boat operation is prevalent, this can be a severe condition.
3. Current Velocity -- When the velocity of the water is high enough to move particles of silt or sand, washing or undercutting can occur.
4. Leaching and Piping -- Where shore lines are high or steep, surface or underground drainage can cause washing out of fine materials destroying the stability of the river banks.

5. Pond Drawdown -- Although the descent of the adjoining water level actually increases the stability of banks composed of incompressible soils, it reduces the stability of banks composed of compressible soils since water is retained in the bank by capillary forces and a volume decrease takes place due to consolidation.
6. Other Factors -- Banks may be kept raw by the passage of cow herds, may be honeycombed by bank swallows, may be weakened by falling trees, or may be affected by human disruption such as vegetative clearing, earth moving, building and paving.

## II. OPERATION OF PONDS

### 1. Drawdown Limits

At Wilder Dam, normal pond elevation varies from 385.0 to 380.0 msl. At Bellows Falls Dam, normal pond elevation varies from 291.63 to 287.63 msl. At Vernon Dam, normal pond elevation varies from 220.13 to 212.13 msl.

It should be noted that, because of backwater effects, the variation can be much greater than this at the upper reaches of the ponds, depending on the magnitude of river flow. This variation, however, is still much less than the variation of natural river elevations without the dams.

Except under emergency conditions, water level is never drawn below these limits.

### 2. Rates of Drawdown

At Wilder Dam, the pond cannot be drawn more than 0.4 feet per hour, measured at the dam, by generation alone, even with no inflow.

At Bellows Falls Dam, the amount of generation for a given pond elevation is limited in order to limit the velocity in the Bellows Falls Canal to 6 feet per second. This restriction limits the drawdown of the pond to 0.4 feet per hour, measured at the dam, by generation alone, even with no inflow.

At Vernon Dam, the pond cannot be drawn more than 0.5 feet per hour, measured at the dam, by generation alone, even with no inflow.

It is, of course, possible to draw the ponds at faster rates by gate operation. However, to prevent the quantity of water being discharged from greatly exceeding the inflow thereby increasing the magnitude of downstream flooding, restrictions are imposed during high water periods which limit drawdown rates to less than those listed above for generation alone.

Because of backwater effect and upstream natural channel controls, the amount of drawdown, as measured at the various dams, diminishes progressively as one moves upstream. Consequently, a rate of draw established at the dam would be considerably greater under most circumstances than that actually experienced in the upper reaches of the pond.

It should also be noted that the rates and depths of drawdown resulting from natural ice movement may far exceed the operating limitations imposed on the various ponds.

### 3. Inspections

Bank inspections by boat, using maps and photographs, have been made on each of these ponds periodically for over 20 years. Surprisingly, bank erosion has occurred at a much slower rate than one would think from looking at the scars and raw areas. This is borne out by observations made over many years using specific trees or landmarks and comparing the distance of these objects from the top of river bank at each inspection.

Where significant erosion has occurred, it has generally been accompanied by severe flow conditions or heavy ice runs.

## III. EXTENT AND NATURE OF EROSION

Less than ten percent of the shoreline of these ponds shows evidence of erosion. Even this figure is deceptively large, however, since a large proportion of this percentage consists of inactive slide areas, which have stabilized and are healing.

The nature of the erosion indicates that no single factor is responsible. Actually, it appears that a combination of all the causes listed in Section I of this report has led to the existing conditions.

An inspection, including photographs, of sections of the river where no impoundment takes place and of the shoreline of the White River, which has no dams, indicates that erosion is more severe and more extensive in those areas than along the pond banks.

#### IV. RELATION OF PROBLEM TO RELICENSING

In compliance with Federal Power Commission regulations, prior to construction or redevelopment of these three dams, comprehensive flowage rights were obtained from all property owners abutting the pond areas and agreements and indentures obtained from all towns having rights-of-way adjoining the impoundments. In addition, stream bank erosion is considered less severe in the impounded section of the river than in the non-impounded section.

The New England Power Company, therefore, believes there is no erosion problem with regard to relicensing since all regulatory requirements have been met including, at considerable cost, acquisition of all necessary lands and rights for flow along the banks of the impoundments.

#### V. CONCLUSIONS

It is our conclusion that erosion along the banks of Wilder, Bellows Falls and Vernon Dams is a natural phenomenon, attributable to natural causes, and that, rather than adding to this erosion, the Company's operation of these ponds by reducing velocities and fluctuation ranges and by reducing flood discharges through storage in upstream reservoirs, actually decreases the condition, resulting in more stable conditions than exist where no impoundment takes place.

We would discourage the construction of residences within the confines of the flood plain of the Connecticut River, since this introduces problems completely beyond our control.



# EFFECTS OF BANK EROSION ON THE BIOLOGICAL RESOURCES OF THE CONNECTICUT RIVER

U. S. Bureau of Sport Fisheries and Wildlife

## Introduction

There can be little question that a serious silt condition exists in certain sections of the Connecticut River, especially upstream from the Vernon Dam. During the spring and early summer months, the silt load is such that Secchi disc readings are almost non-existent. The disc disappears within a short distance from the surface.

It initially appears that a substantial portion of the silt load in the river is caused by the gradual and continuous sloughing off of the river bank. Although erosion is undoubtedly a common and naturally occurring condition in nature, the situation in the Connecticut River appears to be aggravated by the manipulation of the water levels during hydroelectric power generation. It appears that the constant daily, weekly and seasonal fluctuations preclude the possibilities of the banks ever being able to stabilize themselves with any degree of success.

Abnormal riverine patterns of silt deposition may be seen in river segments directly affected by water level manipulation. This is illustrated in Figure 1.

## Fishery Resources Available

The Connecticut River primarily supports a warmwater fishery resource. Principal game fish species found in the area under investigation include smallmouth and largemouth bass, sunfish, walleye, yellow perch, brown and yellow bullheads, northern pike and chain pickerel. Forage species found in this area include suckers, fallfish, and golden shiners. Bass, sunfish, bullheads, suckers, and fallfish utilize gravel or sand bottoms. Their nests are generally found in a depth range of 2' to 8'.

Utilization of the Connecticut River's fishery resources is currently below the potential support capacity. Increases in human population will probably produce additional fishing pressure upon the main stem Connecticut River. It is, therefore, important to retain the conditions necessary for perpetuation of the fishery resources.

## Preliminary Determination of Erosion Pattern Effects Upon the River's Biological Resources

One of the most significant findings to come from the resident fish population studies on the Connecticut River was the overall low density of the various fish populations. This was particularly obvious in certain areas and in the Vernon Pool.

Not only were there low population densities of adult fishes, but a definite absence of "zero" age class fish; that is, fish of the year which should have been the most prevalent of all. This is a good indication of poor egg hatching. Recent water chemistry tests indicate that water quality is not significantly detrimental to fish species presently populating the river. The absence of substantial members of "fish of the year," may be attributed to two probable causes. These causes are: 1) silt deposition on eggs which resulted in their being smothered and 2) fluctuating water levels leaving eggs exposed during various manipulations of water levels. It should be obvious that either together or separately, the stated conditions would be fatal -- hence, poor year class strength for many species, especially for those species relegated to nesting and spawning in the shallow areas.

Many fish utilize benthic and planktonic organisms as food. Data were not available to determine the effect of siltation upon these organisms at this time.

### Recommendation

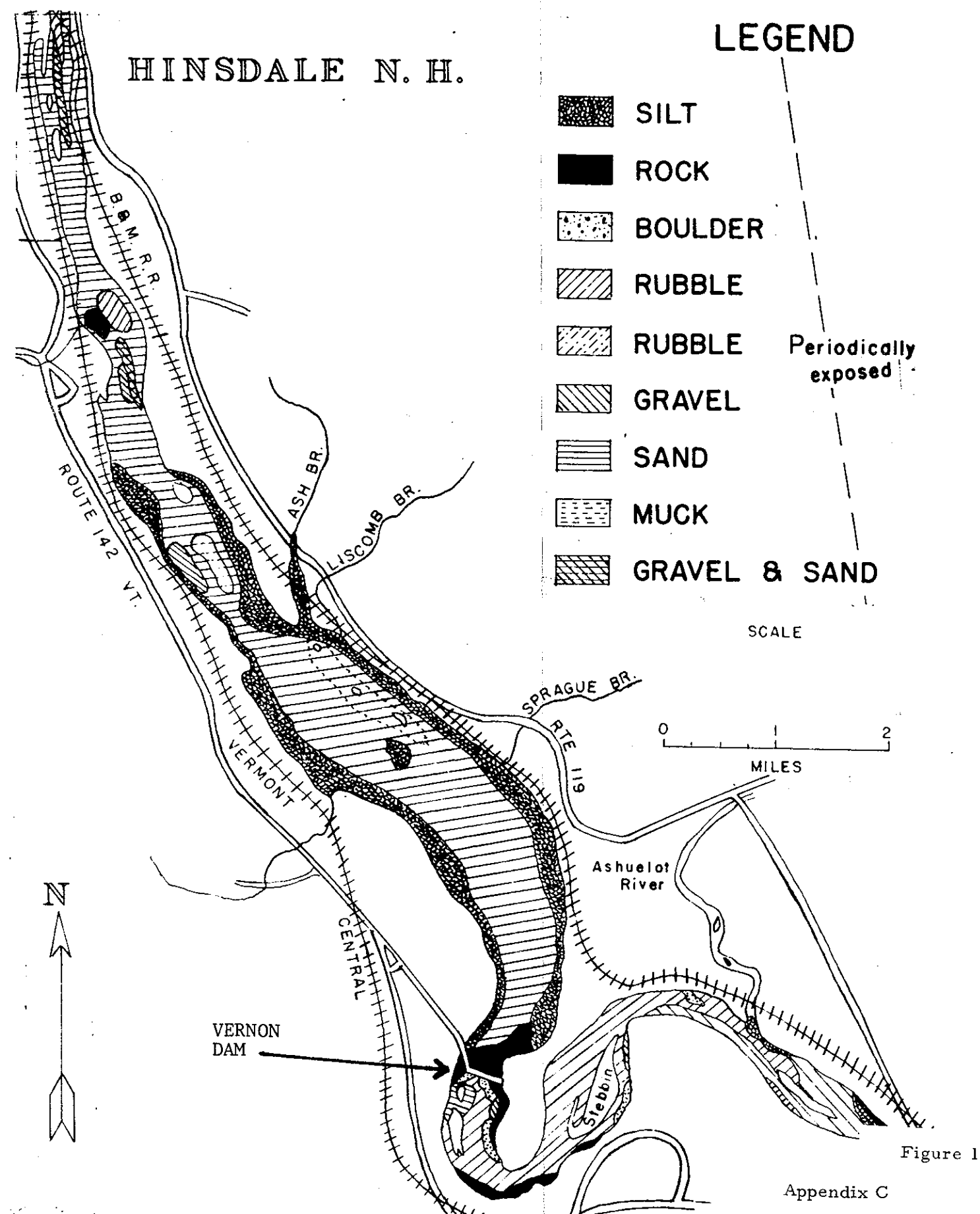
Additional information is needed on both Connecticut River erosion patterns and the subsequent effects upon the biological resources. Power is needed. So are the nation's biological resources. Therefore, it is suggested that an initial examination and a continuous monitoring program be established. It is necessary to continue power generation to determine its effects upon erosion and silt deposition patterns. Adjustments may be able to be made in the mode of operation, which in turn will minimize negative environmental effects.

## Bibliography

Connecticut River Basin Coordinating Committee. 1970 Fish and Wildlife Resources, Appendix G, Volume V, Comprehensive Water and Related Land Resources Investigation - Connecticut River Basin.

Morrison, George. 1968, Resident Fish Population Studies (February 15, 1967 - March 31, 1968). New Hampshire Fish and Game Department.

Morrison, George. 1970, Resident Fish Population Study. (July 1, 1969 - June 30, 1970). New Hampshire Fish and Game Department.



# TECHNICAL REPORT ON THE SEDIMENTATION PROBLEM OCCURRING AROUND THE HYDRO-ELECTRIC POOLS

Environmental Protection Agency

Our files contain no sedimentation information, but according to a map shown to me by the Bureau of Sport Fisheries and Wildlife, there seems to be a bank sloughing and sedimentation problem occurring behind the hydro-electric dams. The evidence shown on the map indicates that the sediment deposits are primarily from drawdown induced slides and groundwater seepage induced slides. The sediments do not appear to be localized around the mouths of any entering streams. However, the sloughing or slumping could be enhanced by local gully-ing induced by runoff from urban areas. The gullies can cause a weakening of the river bank, thus making it more susceptible to other erosion pressures.

The map indicated that the sediment deposits were accumulating to a large extent near shore. This is probably due to the decreased current scouring action in the impoundment. The principle time these sediments would be removed would be during the infrequent periods of ice scour or flooding.

The effects these sediments will have on the impoundment are determined to a large extent on the depth of their deposition. If the deposition occurs below the depth of effective light penetration, the main effect will be the leaching of materials from the newly exposed unstable sediments. However, the water moves out of the reservoir too rapidly to cause any taste and odor problems or ionic buildup which could lead to staining. If the deposition occurs within the depth of effective light penetration, the sunlight could induce plant growth and algal growths or scums along the shores. Whether these would be moved out during flow releases would depend upon the subsequently induced current. This plant growth and possible algal mats would induce only aesthetically displeasing effects because of the limited detention time of the impounded water. The aspect of raw streambanks with trees toppling, or about to topple, into the stream are also aesthetically displeasing. These aesthetic considerations may be important where recreational activity is important.

If excessive erosion and sediment transport are induced by the pool fluctuation, then the problem becomes more severe. Any excessive suspended or transported sediment can cause gill scour, spawning bed destruction, or benthic organism smothering, if severe enough.

Based upon the limited information available, these situations are speculative at this point. However, the situation does seem severe enough to warrant further investigation.

MECHANICS OF STREAMBANK EROSION  
CONNECTICUT RIVER, NEW HAMPSHIRE AND VERMONT

New England Division - Corps of Engineers

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1. Introduction. The following is a brief discussion of the mechanics of streambank erosion along the Connecticut River between the Vernon Dam and the head of the impoundment for the Wilder Dam. The processes of streambank erosion are described and ranked in order of importance. Changes in patterns of streambank erosion attributable to the impoundments for the Vernon, Bellows Falls and Wilder Dams are assessed to the extent allowed by the limited information available.
2. Soils. In the reach under discussion, the Connecticut River flows through areas of variable soil types. For present purposes, these are grouped in three categories: course-grain soils, such as gravel and sandy gravel, exhibiting moderately high resistance to erosion; glacial till soils of variable but generally high resistance to erosion; and fine-grain soils, such as sandy silt and silty fine sand, which are highly erodable. As might be expected, most of the reported streambank erosion problems have occurred in soils of the last group.
3. General. Streambank erosion may be defined as the removal of material from the bank by processes attributable to the action of moving water. The extent and rate of streambank erosion are governed by such factors as climate, topography, soil conditions and conditions imposed by man. Many of these controlling factors vary with time and the overall pattern of streambank erosion is one of constant change. Typical of this situation are such phenomena as the major change in a river course during a flood, the cumulative minor changes in river course constantly taking place in meandering reaches and the transient episodes of bank erosion occurring on a seasonal, or even daily, basis.
4. Processes of Streambank Erosion. The processes by which streambanks are eroded are most often interrelated and frequently concurrent. The predominant process is the removal of bank material by the tractive force of flowing water. From the standpoint of the volume of

material affected, continuity of action and overall effects, this is the predominant process. The removal of bank material by wave action is a significant bank erosion process in reaches of slow flow, as in impounded reservoirs. Ice action is a process of localized importance. Bank slides, while of relatively minor significance with respect to overall effects, often have great local impact.

#### 5. Tractive Erosion.

a. The tractive forces exerted by flowing water upon a stream-bank tend to move soil particles into the current where they are carried downstream and eventually deposited. The speed of this process is governed principally by the direction and velocity of the current, the nature of the bank material and the slope of the bank. Fine-grain soils can be affected by current velocities as low as 2 feet per second.

b. Patterns of tractive streambank erosion change even if the total flow of the stream is constant. The current velocity at a particular point on the bank is partially a function of the cross-section area of the channel and the general direction of flow. As the bank is eroded, the channel area is increased with a resulting decrease in velocity and rate of tractive erosion. The eroded bank material, however, is deposited in the channel further downstream where it reduces the channel area with a resulting increase in velocity and rate of tractive erosion. It is not unusual, therefore, to find particular reaches of a streambank going through cycles of rapid tractive erosion, apparent stability and shoaling over extended periods.

6. Wave Action. Waves striking a shoreline of soil move the soil particles towards the formation of a stable beach profile. The extent and rate of the resulting erosion is governed chiefly by the height of the waves, the character of the soil and the original slope of the shoreline. Wave action erosion, in the area under study, is of potential significance in the impounded reaches where substantially high waves can be generated by the wind or the operation of power boats. It is not known, at present, whether this erosive process of itself has acted to a noticeable extent in the three impounded reaches although the possibility has been recognized by several agencies.

7. Ice Action. Ice in a stream can move bank material by the grinding and gouging action of blocks drifting with the current and by a plucking action as ice formed along the bank is torn loose. While the actual volume of bank material moved by ice action is usually small, the



affected banks are rendered more susceptible to erosion by other processes. Streambank erosion through ice action appears to be a problem only where it has an impact on human activities. Elsewhere, it is only a minor component of the spectrum of erosive processes.

## 8. Slides.

a. Streambank slides involve the sudden movement of soil masses into the stream. The volume of the sliding mass may range from a few cubic feet to thousands of cubic yards. It is unlikely, however, that a slide involving more than a few hundred cubic yards has occurred or will occur in the area of study. Each slide is essentially an adjustment of the bank to a more stable condition. Sliding at a given location, therefore, does not recur until an unstable condition is reinstated.

b. Streambank slides fall into three categories on the basis of causes. The most common type is that resulting from changes in the bank slope caused by tractive erosion, wave action or ice action. The term "undercutting" is often used in this connection, although the slope change causing a slide may not be as extreme as the term indicates. Slides of this type can be of any magnitude but most are small and frequently recurrent where other erosive processes are active.

c. Another type of slide is that caused by changes in internal stresses in the bank resulting from changes in stream level. Although often referred to as "drawdown" slides, they can occur with a rising as well as a falling stream level. The frequency of recurrence of this type of slide is low as long as no great change takes place in the range of stream level fluctuations. This is exemplified by the common experience with new impoundments where "drawdown" slides are numerous during the first year or two and then become very rare. It is possible, however, for tractive erosion or wave action to eventually steepen the banks to a point where a new series of such slides can occur. There is no presently available evidence that this is happening to a significant extent in the reservoirs under study.

d. Changes in the patterns of ground water flow to a stream can cause bank sliding. These changes can be associated with stream level changes or changes in groundwater flows induced by other factors. Slides of this type are usually very small and their effects masked by the results of tractive erosion and wave action. Seepage pressures from ground water flows, however, are very often contributory causes for slides of the "undercutting" and "drawdown" varieties.

9. Impoundment Effects. Impoundment of a stream will affect the pattern of streambank erosion in the impounded reach. In the three reservoirs being considered, it appears that tractive erosion has been reduced, erosion by wave action increased, erosion by ice action unchanged and the incidence of bank slides reduced following a transitory increase during the early years of reservoir operation. It is believed that the net effect of these impoundments has been to reduce the total volume of material moved by bank erosion.

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